Short Communication

Understanding blood and serum values of the agouti (*Dasyprocta* spp.): A rodent of the Neotropics with the potential to be domesticated

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This short communication is intended to provide information on the blood and serum biochemical parameters of the agouti (*Dasyprocta* spp.). Information on blood and serum biochemical parameters of this neo-tropical rodent is very scarce. Three agouti species from the Neotropical region were included in this report: *Dasyprocta leporina*, *Dasyprocta fuliginosa* and *Dasyprocta prymnolopha*. Several blood parameters were similar irrespective of the species, location, physiological state and method of restraint when blood was collected. Some of these parameters were red blood cell count, haemoglobin, haematocrit and mean corpuscular volume. Differences seen in some parameters were attributed to the differences in physiological state or environmental impact on the animal. The literature that was available showed a large time gap of approximately thirty (30) years in the reporting of blood parameters in the agouti. Early work was done in the mid-1970s and then recommenced in the mid-2000s. Some biochemical parameters such as triglycerides, amylase, chloride, sodium, potassium, bilirubin and uric acid were only recorded in the literature once and comparison of values was impossible. These parameters require further investigation which can be done in future studies. The dearth of information on the blood profile of the agouti gives justification for further research to be done in this regard as well as more detailed analysis of the effects that the environment and physiological states may have on haematological and biochemical parameters.

Keywords: Haematological, *Dasyprocta leporina*, *Dasyprocta fuliginosa*, *Dasyprocta prymnolopha*, haemoglobin, haematocrit, mean corpuscular volume

The agouti (*Dasyprocta* spp.) belongs to the rodent family (Nowak and Walker 1999) and is found in the Neotropics from southern parts of North America through Central and South America (Emmons and Feer 1997). These animals have been utilized as a source of meat protein in this region for centuries, and have contributed to food security in many rural villages including through sharing amongst hunters (Nunes et al. 2019). They are regarded as mini-livestock which have tremendous potential to provide meat protein for communities in the Neo-tropics (NRC 1991, Govoni and Fielding 2001; Hardouin et al. 2003), and guidelines for farmed production have been produced (Brown-Uddenberg et al. 2004).

Agoutis are monogastric omnivores with a functional caecum. It has been reported that their feed includes fruits, seeds, forage and animal matter (Garcia et al. 2000; Silvius and Fragoso 2003; Figueira et al. 2014; Lall, Jones and Garcia 2018a; Jones, Lall and Garcia 2019a; Smith and Smith 2019). They were originally reported to be frugivorous (Silvius and Fragoso 2003) but recently Jones, Lall and Garcia (2019a) confirmed that they are indeed omnivores. These animals have long gestation periods of 103-104 days (Sousa et al. 2012; Guimaraes et al. 2016), take nine months to reach sexual maturity (Guimaraes et al. 2009) and have oestrous cycles that range from 28-31 days (Guimaraes et al. 1997; Guimaraes et al.

2009; Guimaraes et al. 2011). There is a dearth of information on the clinical diseases experienced by the agouti. However, there is information on pathogenic organisms harboured by these animals. Pathogenic bacterial organisms such as *Escherichia coli*, *Streptococcus viridans* and *Klebsiella pneumoniae* have been found in the agouti (Adesiyun 1999; Suepaul et al. 2016, Lall, Jones and Garcia 2018b). Viruses such as Mayaro virus (de Thoisy et al. 2003) and parasites also have been found in the blood and gastrointestinal tract (de Thoisy et al. 2000; Lainson, Carneiro and Silveira 2007; Suepaul et al. 2016; Jones and Garcia 2017; Jones and Garcia 2018; Jones, Lall and Garcia 2019b). Surprisingly, the pathogens identified had little or no clinical effect on the agouti in captivity and in the wild. However, their presence represents a potential health and food safety threat for both handlers and consumers.

Given the potential for the increased utilization of these animals for human food, identification of diseases at a sub-clinical level is extremely important whether they are to be multiplied in captivity or collected from their wild environment. One tool in the identification of sub-clinical injury or disease has been the use of blood and serum biochemical values. The agouti has similar blood cell morphology to other mammals (Conde Junior et al. 2012). However, biochemical and blood values have been recorded in agoutis at different locations using various forms of restraints and from animals in different physiological states. This short communication presents a compilation of reported blood and serum biochemical values of the agouti located within the Neo-tropics as baseline reference levels that can be built upon, and suggests the use of these values as the basis for the development of a *Vade Mecum* for the agouti.

Red blood cell parameters

The circulating erythrocytes of the agouti were found to be elliptical without a nucleus. Erythrocytes had an average diameter of 5.64 micrometers (Conde Junior et al. 2012). The agouti has been considered to be semi-domesticated (Brown-Uddenberg et al. 2004). As such, physical restraint has been reported to cause haemoconcentration due to the stress, whilst sedation of the animal can alter its biochemical values (Conde Junior et al. 2012). The haematological values observed showed little difference at different physiological states. Parameters such as red blood cell (RBC) count, haemoglobin, mean corpuscular volume and mean corpuscular haemoglobin concentration were similar irrespective of the location, physiological state and method of restraint. However, it must be noted that animals that were sedated before blood samples were taken had lower values for red blood cells and haemoglobin (Table 1) (Andrade et al. 2011; Baas, Potkay and Bacher 1976).

The higher red blood cell parameters observed in unsedated animals may have been due to the stress associated with the restraint of the agouti. Some authors have suggested that the various species noted in the literature (*Dasyprocta leporina*, *Dasyprocta azarae*, *Dasyprocta fuliginosa*, *Dasyprocta prymnolopha*), may actually be one species with several colour morphisms (Brown-Uddenberg et al. 2004). The similarities in red blood cell values obtained from different species of agouti, agree with the concept that the agouti may be one *Dasyprocta* species with various hair colourations.

Table 1: Haematological (Erythron) values of various agouti species (*Dasyprocta* spp.) at different locations in the Neotropics

Agouti species	Location	Sample size (n)	Physiological States	Red Blood Cells (RBC) $x10^{12}$/l	Haemoglobin (HGB) g/dl	Haematocrit %	Mean Corpuscular Volume (MCV) fl	Mean Corpuscular Haemoglobin (MCH) pg	Mean Corpuscular Haemoglobin Concentration (MCHC) g/dl	Reference
D. leporina	Trinidad (T&T)	10	Adult Males	8.55	16.92	52.97	62.50	19.75	31.91	Jones, Lall and Garcia (2019c)
Dasyprocta spp.	Brazil	5	Adult Males	9.09	17.14	55.20	60.60	-	33.20	de Aquinos et al. (2009)
		5	Adult Females	8.52	15.75	52.60	63.40	-	30.20	
		4	Juvenile Males	7.33	19.90	49.50	67.75	-	40.00	
		6	Juvenile Females	7.47	17.83	46.00	62.50	-	38.83	
Dasyprocta spp.	Brazil	24	Adult Males, Females and Juveniles	6.51	12.71	43.53	67.61	-	29.19	Ribiero et al. (2008a)
D. fuliginosa	Colombia	10	Adult & Juvenile Males	-	16.5	49.90	-	-	-	Nunes et al. (2006)
*D. fuliginosa**	Peru	23	Adult Males, Females and Juveniles	6.17	12.4	40.3	66.6	20.6	30.9	Andrade et al. (2011)
Dasyprocta spp. *	USA	10	-	6.70	13.9	-	71.0	20.6	28.7	Baas, Potkay and Bacher (1976)

*Denotes animals were injected with a sedative before blood samples were collected

White blood cell parameters

White blood cells in the agouti can be divided into granulocytes and agranulocytes. The granulocytes have granules in their cytoplasm and are the neutrophils, basophils and eosinophils. Granulocytes have lobulated nuclei with neutrophils measuring 11 micrometres, eosinophils measuring 14.25 micrometres and basophils measuring 9.8 micrometres. The agranulocytes are monocytes and lymphocytes, with lymphocytes having scarce cytoplasm surrounded by a centralized round nucleus. Monocytes are slightly basophilic with a spherical nucleus (Conde Junior et al. 2012).

White blood cell values recorded in the agouti were similar irrespective of the method of restraint, age, physiological state and species. However, agoutis found in Trinidad had higher white blood cell counts in comparison to those found in agoutis at the other locations (Table 2). These animals in Trinidad were evaluated as being healthy. The apparent high value could be due to various reasons, one being that the agoutis were stressed by physical restraint whilst the blood was being collected. Another possible reason could have been that these animals had higher values because in that environment there were greater numbers of pathogenic invaders or the animals were carriers of low-grade diseases with sub-clinical manifestations. Eosinophilic cell counts were similar for animals in Brazil and the USA but male (adult and juveniles) agoutis in Colombia had higher levels (Table 3). The agoutis reared in Colombia were collected from the wild and could have been exposed to a greater number of endoparasites compared to the animals from the other locations (Nunes et al. 2006), with the high levels being indicative of the presence of sub-clinical diseases.

The individual cell counts for the basophils, monocytes and lymphocytes in the agouti showed little variation in values irrespective of various factors such as physiological state, location and species. However, the percentage values for the white blood cells mentioned above showed great variability. This variability can be attributed to numerous factors, some of which have been mentioned earlier (Tables 2 and 3). This suggests that when analysing white blood cells (lymphocytes, monocytes, basophils, neutrophils, eosinophils) for clinical cases in the agouti, the actual (individual) cell count should be used as it gives more accurate information on the health of the animal.

Table 2: White blood cell parameters (leukon) [White blood cells, lymphocytes and monocytes] values of various agoutis (*Dasyprocta* spp.) at different locations within the Neotropics

Agouti species	Location	Sample size (n)	Physiological States	WBC (10^9/l)	LYM (10^9/l)	LYM (%)	MON (10^9/l)	MON (%)	Ref.
Dasyprocta spp.	Brazil	5	Adult Male	6.70	-	-	-	-	de Aquinos et al. (2009)
		5	Adult Female	7.67	-	-	-	-	
		4	Juvenile Male	8.28	-	-	-	-	
		6	Juvenile Female	8.12	-	-	-	-	
Dasyprocta spp.	Brazil	24	Adult Males, Females and Juveniles	7.24	3.58	50.29	0.76	10.21	Ribiero et al.(2008a)
D. fuliginosa	Colombia	10	Adult and Juvenile Male	6.65	5.13	77.6	-	-	Nunes et al. (2006)
D. leporina	Trinidad	10	Adult Males	12.15	2.08	19.72	0.58	4.76	Jones, Lall and Garcia (2019c)
*D. fuliginosa**	Peru	23	Adult Males, Females and Juveniles	5.74	-	29.65	-	0.26	Andrade et al. (2011)
Dasyprocta spp. *	USA	10	-	6.8	2.98	41.0	0.12	1.8	Baas, Potkay and Bacher (1976)

WBC: White blood cells; LYM: Lymphocytes; MON: Monocytes

Table 3: White blood cell parameters (leukon) [Eosinophils, Basophils and Neutrophils] values of various agoutis (*Dasyprocta* spp.) at different locations within the Neotropics

Agouti species	Location	Sample size (n)	Physiological States	EOS (10^9/l)	EOS (%)	BAS (10^9/l)	BAS (%)	NEU (10^9/l)	NEU (%)	Ref.
Dasyprocta spp.	Brazil	24	Adult Males, Females and Juveniles	0.32	4.63	0.11	1.17	4.63	33.71	Ribiero et al.(2006a)
D. fuliginosa	Colombia	10	Adult and Juvenile male	3.31	5.1	-	-	1.12	17.7	Nunes et al. (2006)
D. leporina	Trinidad (T&T)	10	Adult Males	-	-	-	-	-	76.19	Jones, Lall and Garcia (2019c)
*D. fuliginosa**	Peru	23	Adult Males, Females and Juveniles	-	2.39	-	0.5	-	67.09	Andrade et al. (2011)
Dasyprocta spp. *	USA	10	-	0.43	6.1	0.04	0.06	3.37	47.1	Baas, Potkay and Bacher (1976)

EOS: Eosinophils; BAS: Basophils; NEU: Neutrophils

Serum biochemistry and platelet parameters

In the agouti, serum biochemical parameters such as phosphorus and calcium were reported to vary throughout the gestation period. The phosphorus and calcium levels also varied significantly between pregnant and non-pregnant female animals (de Carvalho et al. 2017). The highest values obtained for calcium and phosphorus were from male animals that were reared in captivity in Trinidad (Jones, Lall and Garcia 2019b) (Table 4). The calcium and phosphorus levels in pregnant female animals were lower compared to levels in non-pregnant females, a result that was not unexpected since these minerals are essential for the developing foetus (de Carvalho et al. 2017). The high levels of calcium and phosphorus observed in the blood of agoutis in Trinidad may have been as a result of the animals consuming a diet rich in these minerals.

Biochemical parameters that were similar irrespective of the species, location and physiological states were glucose, blood urea nitrogen, cholesterol, total protein, bilirubin and creatinine (Tables 4 and 5). Differences were found in albumin and globulin values. Animals (adult male, adult female and juvenile) sampled from the wild in Brazil (2.07g/dl) had lower albumin values compared to levels in captive- reared animals in the USA (5.6g/dl) and Trinidad (5.65 g/dl) (Table 5). The low blood albumin values noted may be indicative of diets low in protein, liver pathology or protein being lost from the urinary tract or the gastrointestinal tract. Ribiero et al. (2008a) noted that these animals were physically healthy when samples were taken and therefore one can suggest that the low albumin values may have been attributed to a low protein diet.

The serum globulin values also showed similar variation in the agouti at different locations. Agoutis sampled from the wild in Brazil (3.97g/dl) had higher values in comparison to captive-reared animals in the USA (2.04 g/dl) and Trinidad (0.04 g/dl) (Table 5). The higher globulin levels seen in wild agoutis in Brazil may have been due to the effect of the environment on the animals' immune system. In the wild, animals will be exposed to higher levels of pathogens compared to captive-reared animals and, as such, the wild animals will naturally have a higher level of globulins in the blood (Malan et al. 1997).

Literature on some serum biochemical parameters was very scarce and in some cases, only one record was available. Therefore, comparison of these values was not possible with respect to differences in location or species. These parameters were alanine amino transferase, lactate dehydrogenase, aspartate aminotransferase, gamma glutamyltransferase, triglycerides, amylase, chloride, sodium, potassium, bilirubin and uric acid (Tables 6 and 7). Hence, more information on these parameters is necessary to monitor subclinical illnesses in these animals.

Platelet values for animals reared in captivity in Trinidad (178.9 $x10^9$/l) and Brazil (150.8 $x10^9$/l) were similar. In contrast, agoutis captured from the wild in Brazil had significantly higher values; adult females (319 $x10^9$/l), adult males (342.2 $x10^9$/l), juvenile males (312.26 $x10^9$/l) and juvenile females (530.16 $x10^9$/l) (See Table 6). This vast variation in platelet values among animals can be due to two reasons. Firstly, the collection technique and transportation of the samples may give platelet values that are erroneously high as a result of clumping of the platelets in the sample. Secondly, animals reared in the wild environment must be adapted to allow fast clotting of their blood to avoid detection by predators in the case of injury. Thus, high levels of platelets will facilitate rapid clotting of blood when the animal is injured. Animals that were captive-reared may not have as great clotting ability as the wild-caught animals.

Table 4: Serum biochemical values (calcium, phosphorus, glucose, blood urea nitrogen, uric acid and Cholesterol) of various agoutis (*Dasyprocta* spp.) at different locations within the Neo-tropics

Agouti species	Location	Sample size (n)	Physiological States	Calcium (mg/dl)	Phosphorus (mg/dl)	Glucose (mg/dl)	Blood urea nitrogen (mg/dl)	Uric Acid (mg/dl)	Cholesterol (mg/dl)	Ref.
Dasyprocta spp.	Brazil	24	Adult Males, Females and Juveniles	7.62	3.91	-	-	-	-	Ribiero et al. (2008b)
D. fuliginosa	Colombia	10	Adult and Juvenile Male	-	-	249.9	-	-	108.1	Nunes et al. (2006)
D. leporina	Trinidad	10	Adult Males	10.4	7.48	170	6.6	-	-	Jones, Lall and Garcia (2019c)
Dasyprocta spp. *	USA	10	-	8.7	2.8	199.0	5.3	1.8	86.3	Baas, Potkay and Bacher (1976)

Table 5: Serum biochemical values (total protein, albumin, globulin, A/G ratio, bilirubin and alkaline phosphatase) of various agouti (*Dasyprocta* spp.) species at different locations in the Neo-tropics

Agouti species	Location	Sample size (n)	Physiological States	Total Protein (TP) (g/dl)	Albumin (A) (g/dl)	Globulin (G) (g/dl)	A/G ratio	Bilirubin (mg/dl)	Alkaline Phosphatase (units)	Ref.
Dasyprocta spp.	Brazil	24	Adult Males, Females and Juveniles	6.04	2.07	3.97	0.52	-	26.95	Ribiero et al. (2008a,b)
D. fuliginosa	Colombia	10	Adult and Juvenile Male	5.7	-	-	-	-	-	Nunes et al. (2006)
D. leporina	Trinidad	10	Adult Males	5.99	5.65	0.04	-	0.39	130	Jones, Lall and Garcia (2019c)
Dasyprocta spp. *	USA	10	-	6.6	5.6	2.0	2.4	0.2	82.6	Baas, Potkay and Bacher (1976)

Table 6: Platelets and serum biochemical values (LDH, platelets, AST, GGT, ALT) of various agouti (*Dasyprocta* spp.) species at different locations in the Neo-tropics

Agouti species	Location	Sample size (n)	Physiological States	LDH (IU)	Platelets (10^9/L)	AST (IU)	GGT (IU)	ALT (IU)	Ref.
Dasyprocta spp.	Brazil	24	Adult Males, Females and Juveniles	-	150.8	119.54	25.34	28.08	Ribiero et al.(200b)
D. leporina	Trinidad	10	Adult Males	-	178.9	-	-	46.8	Jones, Lall and Garcia (2019c)
Dasyprocta spp.	Brazil	5	Adult Male	-	342.2	-	-	-	De Aquinos et al. (2009)
		5	Adult Female	-	319.8	-	-	-	
		4	Juvenile Male	-	312.26	-	-	-	
		6	Juvenile Female	-	530.16	-	-	-	
Dasyprocta spp. *	USA	10	-	121.0	-	74.0	-	-	Baas, Potkay and Bacher (1976)

LDH; Lactate Dehydrogenase, AST; Aspartate aminotransferase, GGT: Gamma Glutamyltransferase, ALT: Alanine Aminotransferase

Table 7: Serum biochemical values of three agouti species (chloride, sodium, potassium, triglycerides, creatinine, amylase) (*Dasyprocta* spp.) at different locations in the Neo-tropics

Agouti species	Location	Sample size (n)	Physiological States	Chloride (mg/dl)	Na (mmol/l)	K (mmol/l)	Triglycerides (mg/dl)	Creatinine (mg/dl)	AMY (IU/l)	Ref.
Dasyprocta spp.	Brazil	24	Adult Males, Females and Juveniles	58.69	-	-	-	-	-	Ribiero et al.(2008b)
D. fuliginosa	Colombia	10	Adult and Juvenile Male	-	-	-	78.2	1.7	-	Nunes et al. (2006)
D. leporina	Trinidad	10	Adult Males	-	145	8.2	-	1.1	707	Jones, Lall and Garcia (2019c)

Na: Sodium; K: Potassium; AMY: Amylase

Conclusion

Blood and serum biochemical parameters in the agouti (*Dasyprocta* spp.) showed many similarities irrespective of the animals' physiological state, location, method of restraint and species. This indicated that the three species of agouti (*Dasyprocta leporina*, *D. fuliginosa* and *D. prymnolopha*) reported, may be actually one species with several colour morphisms. Blood values that were similar were: red blood cell count, haemoglobin, haematocrit and MCV. White blood cell (neutrophils, monocytes, lymphocytes, and basophil) count showed less variability compared to the percentage values. Therefore, the actual cell count was a more accurate value for use in the determination of the health status of the agouti.

Serum biochemical parameters, such as albumin, globulin, phosphorus and calcium were different depending on the animal's physiological state and location. Pregnant animals had lower calcium and phosphorus levels in comparison to non-pregnant animals. Platelet values were higher in wild animals in Brazil, compared to captive-reared animals in Trinidad and Brazil. Some parameters such as alanine aminotransferase, aspartate aminotransferase, gamma glutamyltransferase, lactate dehydrogenase, triglycerides, amylase, chloride, sodium, potassium, bilirubin and uric acid were only recorded in the literature once and comparison of values was not possible. These parameters require further investigation.

Recommendation

Specific experiments need to be conducted on the effect of diet and location (captive vs wild-caught) on blood and serum parameters in order to determine the range for healthy agoutis under given conditions. It is recommended that the gaps identified on diseases in captive reared agoutis should be addressed through further research so that a comprehensive compilation will become available for use in the identification of sub-clinical, zoonotic diseases that are of concern to human health and well-being.

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