

Hematology and Biochemistry in Northern Portugal

Erinaceus europaeus

Subjects: Veterinary Sciences

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The Western European hedgehog (*Erinaceus europaeus*) is an insectivorous animal with an extensive geographic distribution. Owing mostly to climate changes and anthropogenic pressures, hedgehogs live now in urban areas close to humans where it is exposed to contaminants and biological agents that may result in disease with the correspondent hematological and biochemical alterations. These animals can work as bioindicators to environmental pollution and host multiple zoonotic agents making them relevant for a One Health approach. Reference intervals for the usual hematological and biochemical parameters are very important since they are important medical decision criteria used to determine the animal's health status or to identify disease.

Keywords: *Erinaceus europaeus* ; Western European hedgehog ; Hematology ; Biochemistry ; Proteinogram ; Reference Intervals ; Northern Portugal ; Wild Life ; Wild Life Rehabilitation Center

1. The Species – Western European hedgehog (*Erinaceus europaeus*)

The Western European hedgehog, *Erinaceus europaeus*, belongs to the mammal order Eulipotyphla, family Erinaceidae, subfamily Erinaceinae, and genera *Erinaceus* ^[1]. There are two species of hedgehog in Europe, *Erinaceus europaeus* and *Erinaceus roumanicus*. *E. europaeus* may be found in western and central Europe, including Britain, the Mediterranean Islands, southern Scandinavia, and into Estonia and northern Russia ^{[2][3]}. It is also the most common species in Portugal ^{[4][5]}.

Hedgehogs are very primitive mammals and have several plesiomorphic characteristics in their morphology, physiology, and behavior. Being nocturnal, terrestrial and insectivores, their dominant senses are the hearing and the smell ^[1]. Animal's anatomy is similar to other small animals but there are some differences such as the collection of cutaneous spines that are arranged dorsally and overlie a variable layer of loose fat and subcutaneous tissue ^[2]. Spines are essential for the animal's defense mechanism, as they threaten its predators ^[6].

The species *E. europaeus* is on the International Union for the Conservation of Nature (IUCN) and Red Book of Vertebrates of Portugal (LVVP) red list, as being “least concern” because it is abundant through its wide range ^{[5][7]}. However, in the last decades, there are records of a reduction in the number of individuals ^[8] which can be justified by several factors: the Western European hedgehog has some natural predators that pose a threat to the survival of the species, badgers (*Meles meles*) are the most significant ones ^{[9][10]} as the hedgehog occupies agricultural areas, it is frequently exposed to poisoning by pesticides and rodenticides ^[11]; the transformation and fragmentation of its habitat, as well as climate changes, affect its survival ^[12]; they are one of the vertebrates that frequently suffer mortality owing to road traffic ^[8] and finally, they harbor a wide variety of different parasites and pathogens ^{[9][13][14]}.

The natural habitat for this animal involves forests, grassland, scrub or cultivated areas ^{[2][4]}. However, due to different pressure factors, hedgehogs are moving close to humans and urban centers, adapting to new territories, food resources (as pet food), and refugia (as public and private gardens) ^{[12][15][16][17]} where they are exposed to biological agents and contaminants, that may result in illness with the correspondent hematological and biochemical alterations ^[18].

Hedgehogs' ecological and feeding habits, as well as their high population densities and repeated contacts with wild and domestic animals and humans, make this species a possible sentinel for a One Health approach, mainly owing to its possible involvement in the ecology of potentially emerging pathogens ^{[19][20]}, such as endoparasites (*Crenosoma striatum*, *Capillaria aerophila* (syn. *Eucoleus aerophilus*), *Capillaria* spp., coccidia, *Cryptosporidium* spp., *Brachylaemus* spp., and *Capillaria hepatica*) ^[13]. Published systematic reviews show that *E. europaeus* may harbor zoonotic pathogens and that the species can play an important role in the epidemiology of various zoonotic infections. The prevalence of zoonotic agents in hedgehogs, from both urban and rural habitats, is of major concern because there is a high probability

of contact with humans and companion animals. Recently, several studies have shown that *E. europaeus* can harbor methicillin-resistant *Staphylococcus aureus* (MRSA) and that this resistance can predate the human discovery of antibiotics [21][22]. For this reason, studying *E. europaeus* populations is highly relevant [23][24].

2. Reference Intervals

Reference intervals (RI) are ranges calculated from a group or population of healthy individuals of a given species and are most widely used as a medical decision-making tool, serving as the basis of laboratory testing, differentiating whether or not a patient is healthy [25]. In order to determine RI, the American Society of Veterinary Clinical Pathology (ASVCP) established guidelines with specific recommendations where it is necessary to define the population of interest as well as criteria to confirm the health status of selected individuals and laboratory procedures [26].

Studies in the literature describing RI for hematological and biochemical parameters for *E. europaeus* are scarce [18][27][28]. It should be noted that the effects of sex and age on these parameters are not necessarily uniform across geographic locations. So, for further studies, the inclusion of several different locations in an assessment or a meta-analysis should be noted. Therefore, it is really important that investigations are carried out in distinct countries/regions for a clear understanding of normal values, and thus cooperate for the improvement of the species' conservative status. Moreover, pre-analytical and analytical factors such as the diet and the effects of stress in captivity and during handling should be taken into consideration when interpreting the results, as it could influence the results and, thereby, the RI determined [29].

This study provides reference intervals for a wide range of hematological and biochemical parameters (routine and electrophoretic) for a population of healthy individuals of the species *Erinaceus europaeus*, in Northern Portugal.

Reference intervals of normal hematological parameters in healthy individuals of the species *Erinaceus europaeus*, from Northern Portugal are provided in **Table 1**.

Table 1. RI of hematological parameters in healthy animals of the species *Erinaceus europaeus*, from Northern Portugal.

Parameters	RI
RBC (M/ μ L)	4.1-10.2
HCT (%)	19.4-41.1
HGB (g/dL)	6.6-13.8
MCV (fL)	34.3-55.8
MCH (pg)	12.0-19.1
MCHC (g/dL)	30.9-36.4
RDW (%)	22.5-35.6
RETIC (K/ μ L)	11.5-705.7
WBC (K/ μ L)	2.5-15.7
%NEU	23.8-81.6
%LYM	14.6-59.9
%MONO	3.5-24.4

%EOS	2.4-26.9
%BASO	*
NEU (K/ μ L)	0.8-10
LYM (K/ μ L)	0.4-6.3
MONO (K/ μ L)	0.2-1.4
EOS (K/ μ L)	*
BASO (K/ μ L)	*
PLT (K/ μ L)	31.3-567.1
MPV (fL)	13.2-17.9
PCT (%)	0.1-0.8

*Given the low number of circulating eosinophils and basophils it was not possible to determine RI for these populations.

RBC, Red Blood Cells; HCT, Hematocrit; HGB, Hemoglobin; MCV, Mean Cell Volume; MCH, Mean Corpuscular Hemoglobin; MCHC, Mean Corpuscular Hemoglobin Concentration; RDW, Red Blood Cell Distribution Width; %RETIC, Reticulocyte percent; RETIC, Reticulocyte count; WBC, White Blood Cell; %NEU, Neutrophil percent; %LYM, Lymphocyte percent; %MONO, Monocyte percent; %EOS, Eosinophil percent; %BASO, Basophil percent; NEU, Neutrophil count; LYM, Lymphocyte count; MONO, Monocyte count; EOS, Eosinophil count; BASO, Basophil count; PLT, Platelet count; MPV, Mean Platelet Volume; PCT, Plateletcrit. Results obtained with the use of ProCyte Dx (IDEXX) hematology analyzer.

The routine biochemical RI for the parameters normally evaluated in clinical practice are described on **Table 2**.

Table 2. RI of routine biochemical and protein electrophoresis parameters in healthy animals of the species *Erinaceus europaeus*, from Northern Portugal.

Parameters	RI
Glucose (mg/dL)	57.0-160.0
Total Proteins (g/dL)	3.4-8.3
Albumin (g/dL)	2.1-4.5
Alkaline Phosphatase (U/L)	19.2-217.8
Creatinine (mg/dL)	0.1-0.9
Phosphorus (mg/dL)	2.7-12.7
Total Calcium (mg/dL)	5.6-11.5

Triglycerides (mg/dL)	22.9-88.5
Gamma-GT (U/L)	1.8-151.8
Globulins (g/dL)	0.4-4.7
Aspartate Aminotransferase (U/L)	10.8-38.7
Sodium (mmol/L)	129.8-153.1
Potassium (mmol/L)	2.5-5.4
Chloride (mmol/L)	100.3-120.1
Proteinogram	
Albumin (g/dL)	1.7-3.5
α 1-Globulin (g/dL)	0.3-0.9
α 2-Globulin (g/dL)	0.2-0.9
β -Globulin (g/dL)	0.6-3.4
γ -Globulin (g/dL)	0.0-0.1

In **Figure 1** there is an example of the electrophoretic pattern of a healthy *Erinaceus europaeus* individual. Medium values for each category are expressed in **Table 2**.

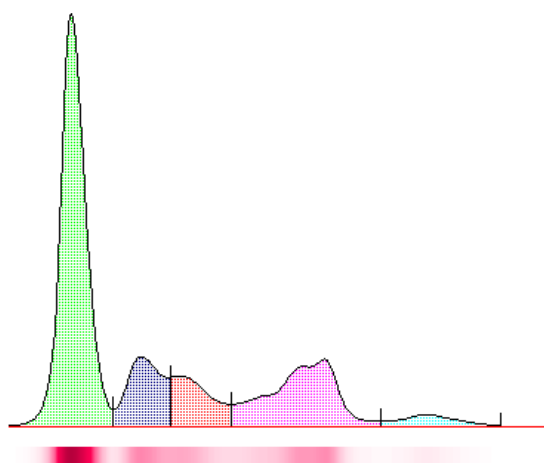


Figure 1. Electrophoretic pattern of a healthy individual of the species *Erinaceus europaeus*, respectively. Green- Albumin; for globulins: Dark Blue- α 1; Red- α 2; Pink- β ; Light Blue- γ .

3. Conclusions

The Western European hedgehog is a mammal with an extensive geographic distribution that, because of climatic changes and other aspects, began to live in urban areas near humans where it is exposed to several anthropogenic pressures, suffering a progressive reduction in population. Hematological and biochemical RI studies on this species are scarce and there is a need to continue performing such type of investigations.

This work provides reference intervals for a wide range of hematological and biochemical parameters covering the majority of the values used in the clinical practice for hedgehogs of the species *Erinaceus europaeus* from Northern Portugal and thus contributing to species conservation and a better understanding of the impact in the human-hedgehogs health interface.

RI obtained in this study do not always fit those previously published in the literature, for populations with different geographic locations, concluding the necessity to create appropriated RI for the target population. However, in the absence of RI in similar populations from other geographic locations these values can be used as a guide.

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