BLOOD BIOCHEMICAL BASELINE VALUES IN THE OSTRICH (*STRUTHIO CAMELUS*)

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Introduction

Ostrich bredding became popular in Italy towards the end of the ‘80s and has now become an important reality in Italian farming. Initially, ostrich breeding was a pioneer phenomenon, characterized by economic advantages with relatively low costs. New legislation regarding slaughter and increased interest by consumers has resulted in an ever-expanding number of breeding farms and animals.

Earnings at slaughter for 14-16 month-old ostriches is approximately 35%, 50% of which derives from ostrich skins. Ostrich meat is high in protein, low in fat and the taste is appreciated by consumers (Minelli et al.,1995).

There are numerous health problems in ostriches reared in captivity and include infectious diseases (viral, bacterial, micotic and parasitic) and non-infectious syndromes associated with husbandry, incubation, diet and metabolism (Catelli and Piazza, 1995; Shakespeare, 1995). Diseases associated with poor breeding and farming practices are quite common, due not only to the the environmental and dietary stress that these animals undergo, but also to the inexperience of many breeders. In fact, a recent survey has shown that 63% of ostrich breeders had no previous experience in animal rearing. Blood biochemistry is often the only means by which metabolic and nutritional problems can be diagnosed with certainty. Dietary deficiencies are common among the breed, due to errors in feed formulation, mixing and stocking (Tullio, 1998). Blood chemistry profiles are extremely important in the health management of this species (Tully and Shane, 1998). This work is aimed at determining baseline values for several parameters, based on age and egg deposition, in apparently healthy ostriches raised in Italy.

Materials and methods

Animals.

Four hundred and six ostriches from different breeding farms were studied. Selected farms featured semi-intensive breeding practices with out-door paddocks. The number of reproducing females ranged from 3-15 for each farm. Ostriches were divided into five groups for the study, based on age and type of diet (see table 1). In

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TABLE 1: Groups of animals

GROUP	AGE (month)	SEX (n)
GROUP 1	3-12	male (16), female (22)
GROUP 2	12-24	male (18), female (16)
GROUP 3	24-36	male (6), female (14)
GROUP 4	36-48	male (55), female (51)
GROUP 5	all subject	male (105), female (103)

groups 1-4, animals received the same kind type of commercial feed in pellets, designed for ostriches, that was integrated with alfalfa (spring and summer) and with hay (fall-winter), administered *ad libitum*. Feed composition was different for different age groups: 1st period feed, until 30-40 days of age; 2nd period feed until egg deposition/slaughter; breeding feed for reproducing animals. Group 5 animals were fed a different commercial feed. Drinking water was administered *ad libitum*.

Animals either born in Italy or imported at least one year previously were included in the study. All animals were appeared in good health.

Blood samples

Blood was drawn form each animal from the wing vein with a 21G needle and a 5ml syringe. Animals had their heads covered in a woolen sock during sampling for ease of containment. Blood was placed in tubes with lithium heparin and kept refrigerated. In the laboratory, samples were centrifuged at 1600 g for 15 minutes and the resulting plasma was stocked at -20 until use.

Profiles

Plasma samples were evaluated for different biochemical values (see table 2). Values were obtained using an automatic photometer (Cobas Mirra plus - Roche, Milan), following the indications for each single kit (Linea Unirate-Roche Diagnostic System and Linea Centro-Roche Diagnostic System - Milan) at 25° C.

TABLE 2: Blood biochemical values

BIOCHEMICAL PARAMETERS	BIOCHEMICAL PARAMETERS
creatinine (CREA: mg/dl)	alkaline phosphate (ALP: U/l)
bood nitrogen (BUN: mg/dl)	lactate dehydrogenase (LDH: U/l)
uric acid (UA: mg/dl)	creatine kinase (CK: U/l)
total protein (PT: g/dl)	calcium (Ca: mg/dl)
albumin (ALB: g/dl)	inorganic phosphate (P: mg/dl)
total bilirubin (BIL. TOT.: mg/dl)	sodium (Na: mEq/l)
aspartate transaminase (AST/GOT: U/l)	potasssium (K: mEq/l)
alanine transaminase (ALT/GPT: U/l)	chloride (Cl: mEq/l)
γ-glutamyltransferase (GGT: U/l)	

Statistical analysis

Results were analyzed by ANOVA, according to the SAS method. Results are given as mean ±SD. Student *t* was used to compare the mean data between sexes and among age groups.

Results

The results of the parameters considered in the study are summarized in tables 3-7. For several parameters, values were from a single subject and therefore not included in the results. Heamolysis was observed in 5% of samples. Group 1 animals showed significant differences between males and females for values of total bilirubin (prob>F'=0,0000), GPT (prob>F'=0,0185), GGT (prob>F'=0,0000), LDH (prob>F'=0,0000) and ALP (prob>F'=0,0000); Group 2 animals showed significant differences between sexes for PT (prob>F'=0,0004), total bilirubin (prob>F'=0,0000), and GOT (prob>F'=0,0000); Group 3 females had significantly higher values than males for PT (prob>F'=0,001) and total bilirubin (prob>F'=0,05), while males had higher values for Ca (prob>F'=0,001); Group 4 animals showed significant differences between males and females for PT (prob>F'=0,0001), total bilirubin (prob>F'=0,0567), and Ca (prob>F'=0,002); Group 5 animals showed significant differences between the sexes, that were not correlated to age or feed composition, for total bilirubin (prob>F'=0,0001), ALP (prob>F'=0,0001), Ca (prob>F'=0,0068) and K (prob>F'=0,0326).

TABLE 3: Blood biochemical values in Group 1

BIOCHEMICAL PARAMETERS	MALE Mean (std dev)	FEMALE Mean (std dev)
CREA	0,26 (0,35)	-
BUN	3,43 (1,49)	5,00 (0,00)
UA	8,83 (4,25)	10,47 (3,88)
PT	3,88 (1,47)	4,25 (1,15)
ALB	2,07 (0,72)	1,93 (0,97)
BIL. TOT.	0,31 (0,54)	0,28 (0,25)
AST/GOT	164,03 (45,79)	166,64 (44,71)
ALT/GPT	12,04 (8,31)	18,54 (5,51)
GGT	2,94 (2,51)	5,03 (0,54)
ALP	300,90 (188,88)	258,81 (104,05)
LDH	1095,71 (887,76)	1133,29 (391,41)
CK	1130,17 (755,37)	-
Ca	12,52 (2,59)	11,48 (4,25)
P	5,44 (1,69)	-
Na	99,94 (58,06)	-
K	4,30 (0,79)	-
Cl	71,86 (45,71)	-

TABLE 4: Blood biochemical values in Group 2

BIOCHEMICAL PARAMETERS	MALE mean (std dev)	FEMALE mean (std dev)
CREA	0,77 (0,81)	-
BUN	3,05 (1,99)	3,33 (2,88)
UA	8,08 (4,74)	7,68 (2,18)
PT	5,06 (0,63)	4,85 (1,87)
ALB	2,56 (1,00)	2,14 (1,33)
BIL. TOT.	0,26 (0,24)	0,22 (0,04)
AST/GOT	140,06 (22,16)	170,33 (99,89)
ALT/GPT	10,56 (4,45)	15,16 (6,17)
GGT	3,94 (1,97)	5,00 (0,00)
ALP	195,00 (81,50)	176,83 (67,67)
LDH	975,06 (378,11)	1004,33 (490,05)
CK	137,33 (36,82)	-
Ca	9,85 (3,39)	11,63 (3,95)
P	1,91 (1,35)	-
Na	0,30 (0,36)	-
K	-	-
Cl	6,60 (1,99)	-

TABLE 5: Blood biochemical values in Group 3

BIOCHEMICAL PARAMETERS	MALE mean (std dev)	FEMALE mean (std dev)
CREA	0,39 (0,31)	2,12 (0,25)
BUN	4,02 (4,25)	0,06 (0,03)
UA	10,48 (1,46)	4,74 (1,51)
PT	4,99 (0,46)	4,44 (0,37)
ALB	3,06 (0,67)	2,16 (0,26)
BIL. TOT.	0,18 (0,10)	0,62 (0,36)
AST/GOT	124,61 (21,75)	135,60 (42,71)
ALT/GPT	9,07 (4,59)	8,20 (1,78)
GGT	3,17 (2,00)	-
ALP	162,33 (92,10)	-
LDH	776,92 (236,12)	1394,60 (156,39)
CK	10,00 (2,82)	186,20 (116,99)
Ca	9,85 (4,10)	-
P	2,32 (1,03)	0,48 (0,13)
Na	0,25 (0,35)	0,44 (0,19)
K	0,54 (0,24)	-
Cl	-	4,42 (2,52)

TABLE 6: Blood biochemical values in Group 4

BIOCHEMICAL PARAMETERS	MALE mean (std dev)	FEMALE mean (std dev)
CREA	0,16 (0,03)	-
BUN	4,00 (1,38)	4,55 (0,90)
UA	6,47 (1,37)	7,17 (2,04)
PT	4,19 (2,15)	4,88 (0,48)
ALB	2,42 (1,25)	2,34 (0,85)
BIL. TOT.	0,33 (0,44)	0,40 (0,24)
AST/GOT	134,87 (52,25)	122,90 (36,34)
ALT/GPT	9,31 (4,31)	9,41 (2,53)
GGT	3,17 (2,53)	5,00 (0,00)
ALP	120,61 (65,67)	113,90 (47,78)
LDH	629,20 (348,09)	1047,17 (332,71)
CK	-	-
Ca	13,05 (1,43)	11,96 (4,91)
P	3,41 (0,84)	-
Na	-	-
K	-	-
Cl	-	-

TABLE 7: Blood biochemical values in Group 5

BIOCHEMICAL PARAMETERS	MALE mean (std dev)	FEMALE mean (std dev)
CREA	0,37 (0,51)	0,39 (0,47)
BUN	3,53 (1,49)	3,46 (1,52)
UA	8,67 (3,64)	8,16 (3,51)
PT	4,24 (1,57)	4,45 (1,36)
ALB	2,26 (0,86)	2,15 (0,98)
BIL. TOT.	0,31 (0,45)	0,27 (0,31)
AST/GOT	148,72 (45,04)	147,00 (48,33)
ALT/GPT	10,69 (6,70)	10,07 (7,26)
GGT	3,26 (2,40)	2,94 (2,32)
ALP	236,98 (163,37)	164,82 (94,84)
LDH	901,74 (424,10)	926,58 (407,82)
CK	874,53 (666,15)	986,57 (691,84)
Ca	11,92 (2,86)	14,90 (3,89)
P	4,20 (2,05)	4,76 (1,86)
Na	75,70 (64,95)	102,61 (60,35)
K	3,69 (1,69)	4,13 (2,24)
Cl	67,22 (46,84)	79,07 (43,83)

Discussion and conclusion

Our results suggest the following considerations.

Creatinin, along with blood nitrogen, are excellent indicators of protein metabolism and kidney function. In our study, values for creatinin tend to increase until 24 months of age and then the trend is inversed. These results regard only males, in that the number of females examined was to low to give statistical value. Creatinin is abundant in muscular tissue and serum values can increase following physical exercise, such as that associated with capture of animals for blood sampling.

Blood nitrogen is associated with the urea present in peripheral blood and has been shown to be an indirect indicator of feed protein composition in farm animals (Ubaldi et al., 1982). Blood nitrogen values in male ostriches tended to remain constant throughout the study in the different groups. Females, on the other hand, had higher values at a young age that tended to decline with time; relative values, however, were constantly higher in females compared to males, except in group 3 where the number of animals did not consent this type of evaluation. In group 5, nitrogen levels were lower than those reported for other avian species like chickens and ducks (respectively 11.5 and 9.15) (Salzano and Russo, 1976).

Avian species are urecotelic and eliminate 60-80 % of nitrogen in the form of uric acid (Mushi et al., 2001). In our study, uric acid concentrations were significantly higher in females in group 1 compared to males. With age, these values tended to decline. Only in subjects between 36-48 months of age, an inversion is seen compared to males. Group 5 animals did not show differences between males and females (8,65 *vs* 8,16) for uric acid or for urea (3,5 *vs* 3,46). Uric acid serum levels changes with protein content in feed, quantity of ingested feed and aminoacid requirements for protein synthesis (Costa et al., 1993). It is also associated with water consumption and urine elimination. Indeed, values for serum uric acid decline in broiler chicks according to feed (Liu et al., 1999).

Total proteins (PT) play an important role in transport of vitamines, hormones, enzymes and electrolytes. In our study, PT values increased with age in males until 24-36 months when they began to decline. In females, PT values remain relatively constant. Low values for PT in the forst 12 months of age can be associated with a high incidence of limb deformaties and poor weight gain, given that in this phase, young birds require feed containing high concentrations of quality protein. These results, however, were not observed by us in this study. According to Mushi et al. (1999), ostrich chicks with limb deformaties present high serum values for manganese and zinc compared to normal chicks. PT values also tend to increase with age in emus (Costa et al., 1993) and broilers (Selvaraj et al., 1998). In geese, PT values rise before egg deposition (Lazar et al., 1989). Our results are in contrast with those seen by Palomeque et al. (1991), where young ostriches showed low levels for heamatocrit, heamoglobin, calcium and magnesium, and high levels of PT and potassium.

Serum albumins are also reflected by PT levels. Albumin in fact represents a large part of total proteins and its trend follows that of PT. Albumin levels generally tend to rise when the protein content in feed exceeds the animals’ requirements. This would indicate, as has been suggested by Costa et al. (1993), that the protein content in the feed is more than adequate for the adults in this study.

Bilirubin derives from the brealdown of red blood cells in the spleen and is bound to albumin. In our study, values tended to decline during the first 24 months of age and then began to rise.

GGT is an indicator of primary or secondary hepatic pathology. Values remain relatively constant in our study, while ALT/GPT values are initially high in females from group 1 compared to males of the same group, as do the other hepatic enzymes. However, it is known that this enzyme is also present in muscular tissue (Ubaldi et al., 1982).

AST/GOT showed a similar trend to that of bilirubin. It is located in the cytoplasm and mitochondria and levels tend to rise with extensive destruction of hepatic tissue, therefore being an important diagnostic tool in hepatic, cardiologic and muscular disease. AST/GOT levels are higher in turkeys bred in tropical climates (Makinde and Fatunmbi, 1985). If we compare our results with those of other authors in tropical/sub-tropical conditions (Van Heerden et al., 1985; Okotie-Ebon et al., 1992; Costa et al., 1993), we may suggest the same is true for ostriches. On the other hand, chickens breeding in tropical conditions tends to more easily affect blood cell counts and enzymes (Oyewale, 1987).

Alcaline phosphatase (ALP) is present in nearly all tissues and organs, in particular liver and bone, where it is associated with osteoblastic processes. Values tend to fall progressively with age in both sexes. Values in group 1 were higher than the others, conferming that seen in growing children and young ostriches (Van heerden et al., 1985) and emus (Costa et al., 1993). Values then stabilize in adults. The high values in young animals is associated with osteoblastic processes rather than hepatic disease, as suggested by Costa et al. (1993). Males had consistently higher values for ALP compared to females, conferming that reported by Levy et al. (1989) in both ostriches and turkeys.

Lactate dehydrogenase (LDH) and creatine kinase (CK) are indicators of muscle damage, both scheletal and cardiac, and neoplasia. Both tend to decrease progressively with age in both sexes. Females from group 3 showed an increase in both values and may be due to stress during capture. CK values for ostriches are higher than those reported for other avian species (Levy et al., 1989).

Calcium levels remain constant in females and present higher levels compared to males only in group 2. The low levels, when compared to males, seen in group 4 females may be due to egg deposition and the wide range of values, as indicated by the standard deviation curves, are likely due to the differing thickness, porosity and weight of the shell that are associated with the period of egg production and genetic variations, as reported by Schiamone et al. (2000). In group 5, values are higher compared to the other groups and this would indicate the importance in nutritional composition. Actively breeding animals need a different type of feed than fattening subjects and they are normally fed a feed rich in fibre and calcium and low in protein and fat. Females produce an average of 100 eggs a year and the ostrich is an herbivore, similar to ruminants.

Data for phosphorus is available only for males. It is interesting to note the differences between the Ca:P ration in the groups 1-4: 2.34, 5.15, 4.25, 3.83. In group 5, Ca:P ratio in males is 2.84 compared to 3.13 in females. Ca:P ratio in group 1 is different from that reported in literature (Van Heerden et al., 1985; Levy et al., 1989;

Okotie-Eboh et al., 1992; Fezia et al., 1996). Ca levels are in fact higher than P and this can predispose subjects to lameness, especially in young birds, as reported by Chen et al. (1997).

Other electrolytes considered (Na, K, Cl) in the subjects in groups 1-4 are very low.

This study indicates that in all examined animals, levels of certain enzymes associated with muscle activity, like LDH, CK, GOT, ALT, were increased, particularly in animals from group 1. These values are not significantly different from those reported by other authors (Van Heerden et al., 1985; Levy et al., 1989; Okotie-Eboh et al., 1992; Fezia et al., 1996) and are likely due to muscular stress during capture and containment, especially in young animals that are not used to contact with humans, as suggested by Shao et al. (1999). Indeed, stress during capture can also contribute to sample heamolysis. Andreasen et al. (1997) have shown that heamolysis can later the values of several parameters, like AST, Ca and uric acid in ratites. However, when the results from group 5 are considered, this may have very little influence. Haemolysis occurred in a number of specimen was similar at Van Heerden et al. (1985) data.

If we consider the data obtained by us in animals with differing feed regimens and independently of age, we see that creatinin levels are slightly lower than those given by others. Values for BUN, on the other hand, are quite higher than those reported by Okotie-Eboh et al. (1992).

Serum levels of uric acid are lower in our female ostriches than that reported by Okotie-Eboh et al. (1992)., while they are similar to those described by Tully and Shane (1998).

PT levels in our study are higher than those of Okotie-Eboh et al. (1992) and Tully and Shane (1998), as are albumin concentrations.

GGT values are inversed for sex-association compared to results given by Okotie-Eboh et al. (1992), with higher absolute values than those of other authors.

ALT/GPT values are much lower than values observed by Okotie-Eboh et al.(1992) ALP levels in males were almost twice as much as those seen by Okotie-Eboh et al. (1992) , while values in females corrisponded. We did not observe the high levels that have been reported by Van Heerden et al. (1985). AST/GOT was much lower than values of Okotie-Eboh et al. (1992) for both sexes, but close to ranges described by Tully and Shane (1998). CK values were lower than Okotie-Eboh et al. (1992), while LDH levels were decidely higher. Calcium serum concentrations were slightly higher than values reported by Okotie-Eboh et al. (1992), Tully and Shane (1998) and by Bruning and Dolensek (1986). Inorganic phosphorous was similar in males and females, but lower than values by Okotie-Eboh et al. (1992).

In conclusion, clearly further study is needed to better characterize blood biochemistry profiles in the ostrich in order to furnish the practicing veterinarian the necessary instruments to diagnose and treat common diseases in these species.

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Key words: ostriches, biochemical values, blood, ratites

Parole chiave: struzzo, parametri ematochimici, sangue, ratiti

SUMMARY - Blood samples were collected from 406 ostriches (*Struthio camelus*) kept under semi-extensive conditions. Serum values of uric acid, total protein, albumin, urea, creatinine, creatine kinase, lactate dehydrogenase, aspartate amino transferase, alkaline phosphate, aspartate transaminase, γ-glutamyltransferase, total bilirubin, sodium, potassium, chloride, phosphorus, total calcium were measured.

RIASSUNTO - Sono stati esaminati complessivamente 406 struzzi appartenenti a diversi allevamenti italiani. La tipologia dell'allevamento era semi-intensivo in paddock. Gli struzzi sono stati suddivisi in cinque gruppi in base all'età e al tipo di alimentazione. Sono stati studiati i seguenti parametri ematochimici: acido urico, proteine totali, albumina, urea, creatinina, CK, LDH, GOT, GPT, γ-GT, fosfatasi alcalina, bilirubina totale, sodio, cloro, potassio, fosforo, calcio.

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