ELSEVIER

Comparative Biochemistry and Physiology Part A 137 (2004) 697–701

CBP

www.elsevier.com/locate/cbpa

Nutritional condition and serum biochemistry for free-living Swainson's Hawks wintering in central Argentina

José Hernán Sarasola[a,*], Juan José Negro[a], Alejandro Travaini[b]

[a]Department of Applied Biology, Estación Biológica de Doñana, Avda. de María Luisa s/n, Pabellón del Perú, 41013 Sevilla, Spain
[b]Centro de Investigaciones de Puerto Deseado (UNPA-CONICET), CC 238, 9050 Puerto Deseado Santa Cruz, Argentina

Received 23 September 2003; received in revised form 6 January 2004; accepted 7 February 2004

Abstract

We assessed the nutritional condition and established reference values for serum chemistry parameters in a long distance migrant bird of prey, the Swainson's Hawk (*Buteo swainsoni*), wintering in central Argentina. We analyzed serum concentration of urea, uric acid, cholesterol, and triglycerides and assessed age and sex related differences in these parameters. A body condition index was obtained from the resultant residuals of the regression of body mass and a morphometric measure. No statistical differences were observed among sex and age groups for urea, uric acid and triglyceride serum concentration. However, cholesterol concentration differed among male and female hawks, which could be related to the gain of body mass in wintering grounds at differential rates. The mean values of the four parameters were in the range of those recorded in the Common Buzzard (*Buteo buteo*), indicating good nutritional condition of the population we studied. Forearm length was the morphometric variable that better correlated with body mass. The resultant body condition index was only correlated with triglyceride concentration, suggesting that this index could be valuable in future work dealing with the assessment of body fat storage in wintering and breeding hawks, as well as in stopover points on the migratory route.

Keywords: *Buteo swainsoni*; Cholesterol; Migration; Nutritional condition; Serum chemistry; Swainson's Hawk; Triglyceride; Uric acid; Urea; Wintering grounds

1. Introduction

Reference values for biochemical parameters of free-ranging populations are not only important for veterinarians dealing with captive and rehabilitating animals, but also for studying animals in their natural habitats. Few studies have attempted to establish reference values of biochemical parameters for birds of prey (Ferrer, 1994; Balbontín and Ferrer, 2002; Casado et al., 2002) and most refer to captive individuals under controlled conditions and non-natural diets (Balasch et al., 1976; García-Rodriguez et al., 1987a,b; Ferrer et al., 1987; Polo et al., 1992; Dobado-Berrios et al., 1998).

Swainson's Hawk (*Buteo swainsoni*) is a neotropical bird of prey that breeds in the USA and Canada and migrates to southern South America during the boreal winter in a trip of approximately 10 000 km each way (second in distance among raptors, Fuller et al., 1998). The species has been more extensively studied in North America than in its southern wintering ranges, but there are no studies of biochemical parameters associated with blood in the wild or in captivity. Moreover, no biochemical parameters have been published for

*Corresponding author. Tel.: +34-954-232340; fax: +34-954-261125.
E-mail address: sarasola@ebd.csic.es (J.H. Sarasola).

1095-6433/04/$ - see front matter
doi:10.1016/j.cbpb.2004.02.001

free-living individuals of the genus *Buteo*. The Swainson's hawk makes an interesting model for blood chemistry studies in raptors. While on its breeding grounds, it preys mainly on small mammals, whereas it became an insect-eater on its wintering grounds in Argentina (Jaramillo, 1993; England et al., 1997). In addition, two complementary hypotheses about nutritional and feeding strategies on migration have been asserted and largely debated for this species. The fasting hypothesis proposes that Swainson's Hawks do not feed during the migratory trip to wintering areas and back, using only the fat stored during the premigration interval (Smith et al., 1986), whereas the alternative fat hypothesis suggests that Swainson's Hawks feed *en route* during migration (Kirkley, 1991). Neither of these hypotheses have been adequately tested. The fasting theory is supported only by the absence of regurgitation pellets and feces under trees of communal roost sites used during stopover points in Central America. Studies dealing with the assessment of body condition of hawks captured during stopover in Panama to evaluate their nutritional status have been limited to descriptive and visual evaluations of subcutaneous fat accumulation (Smith et al., 1986). Although hawks have been reported arriving to wintering area in such weak condition that they were picked up by hand (C.C. Olrog in Smith, 1980), no nutritional studies have been conducted for populations of wintering hawks.

The aim of this work is to report reference values of selected serum biochemical parameters that may serve to evaluate nutritional condition of wintering Swainson's Hawks in the wintering season. The influence of other factors on these biochemical parameters, such as sex and age, are also analyzed. We also correlate serum concentration of the biochemical parameters against a body condition index derived from body mass and morphometric measures.

2. Material and methods

Hawks were captured in the vicinity of a roost site in a *Eucalyptus* spp. tree grove near Las Varillas, Córdoba province (31° 58′ S, 62° 50′ W), from 19 to 26 January 2003 (austral summer). We estimated that approximately 600–700 hawks roosted in this site during the trapping period. Trapping was conducted in agricultural fields consisting of continuous croplands, with soybeans as the principal crop. Implanted pastures and natural fields occupied the remaining of the open field surface dedicated to livestock and milk production. Hawks were captured in open fields near the roost using bal-chatri traps (Berger and Mueller, 1959) in early morning and during the afternoon. Traps were set in front of fence posts usually used by hawks for perching, both when they left the roosts in the morning and during late afternoon when they returned to roost. Captured hawks were classified as juveniles or adults based on plumage characteristics, with 2-year-old birds grouped along with juveniles (Wheeler and Clark, 1995). Hawks were banded and weighed with a 1500 g Pesola scale to the nearest two grams. Six morphometric measurements were taken from adults and juveniles. We measured the length of wing chord and tail using a plastic rule to the nearest 1 mm, and length of the exposed culmen, tarsus and hallux claw using callipers to the nearest 0.05 mm. We also measured the forearm length, or the length from the front of the folded wrist to the proximal extremity of the ulna (see Ferrer and De le Court, 1992 for further details) also using a calliper. For a few birds only some of the body measurements were recorded.

Approximately 2 ml of blood were taken from each bird from the brachial vein. The blood was placed in tubes and kept in a cooler until analysis. Biochemical analyses were performed on a digital spectrophotometer within 24 h after blood extraction. Serum concentration of urea, uric acid, cholesterol and triglycerides was measured using enzymatic methods (a commercial kit from Wiener Lab, Argentina). The cellular fraction of the blood sample was used to sex all hawks. For this analysis, we used primers 2550F and 2718R to amplify the W chromosome gene following Ellegren (1996). The sample included 24 males (12 juveniles and 12 adults) and 10 females (5 juveniles and 5 adults).

We used a two-way ANOVA (Zar, 1996) to compare mean values of urea, uric acid, cholesterol and triglycerides among sex and age groups, with male–female and juvenile–adult being the levels of the factors. Due to the lack of normality (Shapiro–Wilk test: $W=0.7$, $P<0.01$), urea concentration was log-transformed prior to analysis. To assess the effect of circadian rhythms, we used *t*-tests (Zar, 1996) to compare serum concentration of metabolites in birds captured in the morning among those captured during the afternoon.

An index of body condition was obtained for the hawks captured. Because Swainson's Hawks are sexually size dimorphic (England et al., 1997) and our sample included adult and juvenile birds, the body condition index was obtained by calculating mass residuals for all birds according to the relationship between body mass and a measure of structural size, correcting thus the body mass for body size differences related to sex and age. For that procedure we correlated the natural logarithm of bird body mass against natural logarithm of each of the morphometric variables measured in hawks by using the Pearson's correlation coefficient. The residuals of the geometric mean regression (Sokal and Rohlf, 1995; see also Green, 2001) among body mass and the better-correlated morphometric variable against body mass were considered as a body condition index of the birds. Relationship among body condition index and biochemical variables were analyzed by the Pearson's correlation coefficient.

3. Results

Thirty-four hawks were captured during the study period. The total sample included 24 males and 10 females of which 17 were adults and 17 juveniles. Twenty-seven hawks were captured in the morning between 06:30 and 10:00 h and the remaining seven were trapped in the afternoon between 14:00 and 20:00 h. Descriptive parameters by sex and age, and values for the pooled sample, are shown in Table 1. Serum concentration of metabolites was similar for birds captured in the morning to those captured in the afternoon (t-test for independent samples: urea $P=0.77$; uric acid $P=0.31$; triglyceride $P=0.91$; and cholesterol $P=0.54$). No significant differences were found between sex and age groups for urea ($F_{sex}=0.27$, $P>0.60$ and $F_{age}=0.50$, $P>0.82$), uric acid ($F_{sex}=0.40$, $P>0.52$ and $F_{age}=0.57$, $P>0.45$), and triglyceride levels ($F_{sex}=0.52$, $P>0.47$ and $F_{age}=2.55$, $P>0.12$). Cholesterol concentration was also similar for adult and juvenile hawks ($F_{age}=0.57$, $P>0.44$), but significant differences were found between mean values of males vs. females ($F_{sex}=8.41$, $P<0.01$). The interaction between age and sex was not significant for any of the parameters analyzed ($P>0.45$ in all cases). The variable with the highest correlation with body mass was forearm length (Table 2). The body condition index resulting from the residuals of this regression was positively correlated with triglycerides concentration ($r=0.38$, $P<0.05$; Fig. 1), but it did not correlate with uric acid ($r=0.15$, $P=0.39$), urea ($r=0.05$, $P=0.76$), and cholesterol levels ($r=-0.16$, $P=0.35$).

Table 2
Correlation coefficients between body mass and each of six morphometric variables measured in Swainson's Hawks (*Buteo swainsoni*) captured in Argentina during 2002–2003 wintering season

	r^2	N	Significance
Forearm length	0.78	33	$P<0.01$
Wing chord	0.75	33	$P<0.01$
Tail	0.61	33	$P<0.01$
Culmen	0.54	31	$P<0.01$
Hallux claw	0.53	33	$P<0.01$
Tarsus length	0.45	33	$P<0.01$

Table 1
Concentration of four serum parameters and body mass (g) in the Swainson's Hawk (*Buteo swainsoni*) while wintering in central Argentina. Biochemical parameter values are in milligram per liter and are given as mean±S.D. with range in the following row

	Males $N=24$	Females $N=10$	Juveniles $N=17$	Adults $N=17$	Total sample $N=34$
Urea	156.6±67.9	173.0±173.6	175.8±136.8	147.0±67.3	161.4±107.2
	(50.0–290.0)	(40.0–630.0)	(40.0–630.0)	(50.0–280.0)	(40.0–630.0)
Uric acid	59.0±20.9	64.7±27.4	64.4±20.3	57.0±25.0	60.7±22.7
	(30.0–94.4)	(21.0–106.0)	(33.0–106.0)	(21.0–97.0)	(21.0–106.0)
Cholesterol	2999.6±790.8	2167.0±628.2	2821.2±812.6	2688.2±870.1	2754.7±831.7
	(1640–4780)	(1330–3200)	(1610±4700)	(1330–4780)	(1330–4780)
Triglycerides	1493.3±478.6	1366.0±476.8	1303.5±422.9	1608.2±485.9	1455.8±474.5
	(790–2580)	(580–2050)	(790–2580)	(580–2480)	(580–2580)
Body mass	960.0±98.0	750.0±57.7	860.3±126.24	764.1±95.08	813.6±120.79
	(845–1110)	(610–860)	(740–1110)	(610–940)	(610–1110)

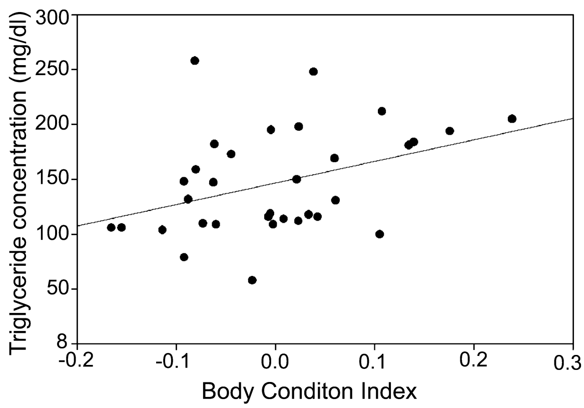

Fig. 1. Relationship between serum triglyceride concentration and the residuals of GM regression between body mass/forearm length (body condition index) for Swainson's Hawks (*Buteo swainsoni*) wintering in Argentina.

4. Discussion

We provide for the first time reference values for four serum biochemical parameters indicative of nutritional condition (Alonso-Alvarez et al. 2002a,b) for free-living Swainson's Hawks wintering in Southern South America. We also considered factors such as sex and age that can influence range and mean values of the respective parameters (Ferrer and Dobado-Berrios, 1998).

High levels of urea and uric acid in several bird species in food deprivation experiments have been related to the catabolism of tissue proteins due starvation (Okumura and Tasaki, 1969; García-Rodriguez et al., 1987b). However, mean values of Swainson's Hawks for urea and uric acid levels were in the range of the lower values obtained by García-Rodriguez et al. (1987b) in the Common Buzzard (*Buteo buteo*), indicating no mobilization of protein reserves and giving evidence of good condition in terms of protein metabolism for the wintering Swainson's Hawks. Serum triglycerides tend to relate to body fat content (Bacon et al., 1989; Dabbert et al., 1997). Thus, the positive correlation we observed between this parameter and the body condition index obtained from the relationship between body mass/forearm length suggests that this index may be used as a measure of fat storage in Swainson's Hawks in future works dealing with fat contents of these birds during migration.

Cholesterol concentration in Yellow-legged Gulls (*Larus cachinnans*) has been related to changes in body mass (Alonso-Alvarez et al., 2002a). Goldstein et al. (1999) observed Swainson's Hawks gaining body mass through the wintering season. The differences that we observed in serum cholesterol concentration among adult male and female hawks could be related to differential rates in gain of body mass in male and female hawks. In birds, cholesterol and triglyceride concentrations are also affected by the qualitative composition of diet (Yeh and Leveille, 1972; Ferrer and Dobado-Berrios, 1998). In the case of Swainson's Hawks, it is unlikely that the dietary shift they undergo between breeding and wintering areas could be a factor influencing the absolute reference values of these two parameters, due similarities in fat content of insects and small mammals. For example, Bird et al. (1982) found mean values of crude fat (measured as percentage of total dry matter) of 6.03% for the red-legged grasshopper (*Melanoplus femurrubrum*) and 6.01% for the meadow vole (*Microtus pennsylvanicus*), which represent the two main prey items of Swainson's Hawks in wintering and breeding grounds, respectively (England et al., 1997).

The absence of significant differences among groups of Swainson's Hawks may be related to the lack of spatial and temporal variations in our sampling. On the positive side, data collection in a short and well-delimited time period reduces temporal biases in nutrient storage, which assure our data reflect the nutritional condition for the entire population studied.

Alonso-Alvarez et al. (2002b) found that breeding produced changes in body mass of Yellow-legged Gulls (*Larus cachinnans*) and also in plasma composition during incubation. It could be expected that Swainson's Hawk biochemical values in North American ranges can be affected by sex and age due to differential energy demands and requirement of birds according to varying demands during different stages of the breeding cycle and also depending on individual levels of parent investment. The hawks that we studied constituted, on the contrary, a rather homogeneous group in terms of behavior and environmental demands, and, therefore our results could be considered as accurate normal values of biochemical parameters for the species.

Acknowledgments

We wish to thank Stella Maris Bacile and Hugo Bergonzi for conducting lab analysis and Noah

Witheman and Ramón A. Sosa for help in trapping and handling hawks during fieldwork. We also thank personnel from Ea. La Independencia and the Agencia Córdoba Ambiente of Córdoba province for giving permission to carry out trapping in the study areas. We thank A. Lanusse and S. Salva for their hospitality and logistic support during fieldwork. J.H. Sarasola had a fellowship from the Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) of Argentina. This study was supported by the Wildlife Conservation Society (USA) and the University of La Pampa (Argentina).

References

Alonso-Alvarez, C., Ferrer, M., Velando, A., 2002a. The plasmatic index of body condition in Yellow-legged Gulls *Larus cachinnans*: a food-controlled experiment. Ibis 144, 147–149.

Alonso-Alvarez, C., Velando, A., Ferrer, M., Veira, J.A.R., 2002b. Changes in plasma biochemistry and body mass during incubation in the Yellow-legged Gull. Waterbirds 25, 253–258.

Bacon, W.L., Nestor, K.E., Naber, E.C., 1989. Prediction of carcass composition of turkeys by blood lipids. Poult. Sci. 68, 1282–1288.

Balasch, J., Musquera, S., Palacios, L., Jimenez, M., Palomeque, J., 1976. Comparative hematology of some falconiforms. Condor 78, 258–273.

Balbontín, J., Ferrer, M., 2002. Plasma chemistry reference values in free-living Bonelli's Eagle (*Hieraaetus fasciatus*) nestlings. J. Raptor Res. 36, 231–235.

Berger, D.D., Mueller, H.C., 1959. The bal-chatri: a trap for the birds of prey. Bird-Banding 30, 18–26.

Bird, D.M., Shio-Kuen, H., Paré, D., 1982. Nutritive values of three common prey items of the American Kestrel. Comp. Biochem. Physiol. A 73, 513–515.

Casado, E., Balbontín, J., Ferrer, M., 2002. Plasma chemistry in booted eagle (*Hieraaetus fasciatus*) during breeding season. Comp. Biochem. Physiol. A 131, 233–241.

Dabbert, C.B., Martin, T.E., Powell, K.C., 1997. Use of body measurements and serum metabolites to estimate the nutritional status of Mallards wintering in the Mississippi Alluvial Valley, USA. J. Wildl. Dis. 33, 57–63.

Dobado-Berrios, P.M., Tella, J.L., Ceballos, O., Donazar, J.A., 1998. Effects of age and captivity on plasma chemistry values of the Egyptian Vulture. Condor 100, 719–725.

Ellegren, H., 1996. First gene on the avian W chromosome (CHD) provides a tag for universal sexing of non-ratite birds. Proc. R. Soc. Lond. B. 263, 1635–1641.

England, A.S., Bechard, M.J., Houston, C.S., 1997. Swainson's Hawk (*Buteo swainsoni*). in: Poole, A., Gill, F., (Eds.), The Birds of North America, No. 265. The Academy of Natural Sciences, Philadelphia, and The American Ornithologists Union, Washington, D.C.

Ferrer, M., 1994. Nutritional condition of Spanish Imperial Eagle nestlings *Aquila adalberti*. Bird Study 41, 120–123.

Ferrer, M., De le Court, C., 1992. Sex identification in the Spanish Imperial Eagle. J. Field Ornithol. 62, 359–364.

Ferrer, M., Dobado-Berrios, P., 1998. Factors affecting plasma chemistry values of the Spanish Imperial Eagle, *Aquila adalberti*. Comp. Biochem. Physiol. A 120, 209–217.

Ferrer, M., García-Rodríguez, T., Carrillo, J.C., Castroviejo, J., 1987. Hematocrit and blood chemistry values in captive raptors (*Gyps fulvus*, *Buteo buteo*, *Milvus migrans*, *Aquila heliaca*). Comp. Biochem. Physiol. A 87, 1123–1127.

Fuller, M.R., Seegar, W.S., Schueck, L.S., 1998. Routes and travel rates of migrating Peregrine Falcons Falco peregrinus and Swainson's Hawks Buteo swainsoni in the Western Hemisphere. J. Avian Biol. 29, 433–440.

García-Rodriguez, T., Ferrer, M., Carrillo, J.C., Castroviejo, J., 1987a. Metabolic responses of *Buteo buteo* to long-term fasting and refeeding. Comp. Biochem. Physiol. A 87, 381–386.

García-Rodriguez, T., Ferrer, M., Recio, F., Castroviejo, J., 1987b. Circadian rhythms of determined blood chemistry values in Buzzards and Eagle owls. Comp. Biochem. Physiol. A 88, 663–669.

Goldstein, M.I., Bloom, P.H., Sarasola, J.H., Lacher, T.E., 1999. Post-migration weight gain of Swainson's hawks in Argentina. Wilson Bull. 111, 428–432.

Green, A.J., 2001. Mass/length residuals: measures of body condition or generators of spurious results? Ecology 82, 1473–1483.

Jaramillo, A.P., 1993. Wintering Swainson's Hawks in Argentina: food and age segregation. Condor 95, 475–479.

Kirkley, J.S., 1991. Do migrant Swainson's Hawks fast en route to Argentina? J. Raptor Res. 25, 82–86.

Okumura, J., Tasaki, I., 1969. Effect of fasting, refeeding and dietary protein level on uric acid and ammonia content of blood liver and kidney in chickens. J. Nutr. 97, 316–320.

Polo, F.J., Celdrán, J.F., Peinado, V.I., Viscor, G., Palomeque, J., 1992. Hematological values for four species of birds of prey. Condor 94, 1007–1013.

Smith, N.G., 1980. Hawk and vulture migration on the Neotropics. In: Keast, A., Morton, E.S. (Eds.), Migrant Birds on the Neotropics: Ecology, Behavior, Distribution and Conservation. Smithsonian Institution Press, Washington, DC, pp. 51–65.

Smith, N.G., Goldstein, D.L., Bartholomew, G.A., 1986. Is long-distance migration possible using only stored fat? Auk 103, 607–611.

Sokal, R.R., Rohlf, F.J., 1995. Biometry. Third ed. W.H. Freeman, New York.

Wheeler, B.K., Clark, W.S., 1995. A Photographic Guide to North American Raptors. Academic Press, San Diego, CA.

Yeh, J.C., Leveille, G.A., 1972. Cholesterol and fatty acid synthesis in chicks fed different levels of protein. J. Nutr. 102, 349–358.

Zar, J.H., 1996. Biostatistical Analysis. Third ed. Prentice Hall, Princeton, NJ.