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Research Article

Modelling the Protein and Amino Acid Requirements of the Greater Rhea (*Rhea americana*)

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Abstract: Protein and amino acid requirements of the Greater rhea (*Rhea americana*) have been estimated from growth data available for this species, and assumptions derived with other closely related species.

Differences in body weight and growth pattern caused considerable higher protein and amino acid requirements for males compared to females after 3 months of age. Whereas the absolute protein requirement is comparable between males (148 g/day) and females (144.5 g/day) at 50 days of age, 21.8 g/day protein is needed by males at 500 days of age compared to 12.2 g/day for females.

Limitations include the lack of knowledge on feed intake and possible digestive adaptations by Greater rheas. However, estimations could serve as a starting point for direct response trials to determine nutrient requirements of the Greater rhea, which could be improved and developed as new information becomes available.

Key Words: Greater rhea, nutrition, protein requirements, model

Introduction

Five subspecies of Greater rhea (*Rhea americana*) and 3 subspecies of Lesser rhea (*Pterocnemia pennata*) have been exploited since pre-Hispanic times in South America for meat, fat, eggs, skin, and feathers (1). Captive breeding of rheas for commercial production started in the early 1990s (2). Whereas farming of Lesser rheas is limited to Argentine and Chilean Patagonia (3), commercialization of Greater rheas has spread outside South America to North America and Europe (2).

Similar to the ostrich, the rhea's digestive physiology is adapted for fiber fermentation in the ceca and colon. Despite some references to the digestive system and feeding habits of the rhea in the wild (4), no research has been conducted until now on the nutrition of rheas reared in captivity.

Knowledge of protein and amino acid requirements is of utmost importance in the nutrition of any species. Dietary protein must supply sufficient levels of essential amino acids to meet requirements, with enough excess amino acids to supply nitrogen needed to synthesize the nonessential amino acids (5). The aim of the present study was to demonstrate how the protein and amino acid requirements of the Greater rhea could be determined through an empirical approach.

Material and Methods

The most common method of determining protein and amino acid requirements is through response studies with increasing dietary levels of specific amino acids. Although requirement is understood to mean a minimal percentage of protein needed for optimal growth with this method, requirement should rather be termed optimal level, because a true requirement is a minimal amount of protein needed per animal per day (6). Emmans and Fisher (7) suggested that, by predicting the rates at which functions occur in the animal's body, protein and amino acid requirements can be determined. This will result in an estimation of the above requirements over the entire life cycle of the animal. The Edinburgh model (7,8) to determine protein and amino acid requirements is based on the description of potential growth of different body components. Calculations used in this model have been described in detail by Sales and Du Preez (9), Sales and Janssens (10,11), and Sales (12) as follows:

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Growth of the body, feathers, and protein weight (C; g) is described by means of the Gompertz equation:

$$C = C_m \times \exp(-\exp(-B \times (t-t^*)))$$

where C_m is the final mature weight (g), B is the maturing rate constant (/day), and t^* is the time from hatching (days).

Growth rate of protein in the empty body (without feathers and gut contents) weight is calculated by:

$$dP/dt \text{ (g/day)} = B^* \times P_m \times u \times \ln(1/u)$$

where B^* (growth coefficient) is $B.P_m^{0.27}$, P_m is the mature protein weight of the empty body weight (g), and

u is the degree of maturing (P_t/P_m),

whereas growth rate of feather protein (FP) is determined by:

$$dFP/dt \text{ (g/day)} = B \times FP_t \times \ln(FP_m/FP_t)$$

where FP_t is the protein weight (g) of feathers at any given time,

FP_m is the final mature feather protein weight (g), and

B is the maturing rate constant for feather protein (/day).

Maintenance protein requirements (g/day) for empty body weight are calculated by:

$$0.008 \times P_m^{-0.27} \times P_t$$

where 0.008 is the ideal protein needed (g/unit), whereas maintenance protein for feathers (g/day) is determined as 1% of feather protein weight per day (8).

Protein requirements needed for growth of either empty body weight or feathers (g/day) are calculated by multiplying the protein growth by 1.25, where 1.25 is the reciprocal of the presumed net efficiency of 0.80. From the above, the total protein requirements (g/day) and, subsequently, individual amino acid requirements can be calculated.

Growth curves described by Navarro et al. (13), with parameters as presented in Table 1, have been used to estimate the protein and amino acid requirements of this species according to the above model. Birds were mainly fed mainly commercially available diets and some had access to pasture, as described in detail by Navarro et al. (13). Several assumptions were applied due to a lack of information on biological characteristics of Greater rheas. It has been assumed that feathers were 1.5% of live weight for all ages and genders (14), whereas protein content was established as 19% and 85% for empty body and feathers, respectively. Protein and amino acid contents of feather-free empty body and feathers were taken to be similar to those of 70-week-old (41 kg body weight) emus (15), presented in Table 2. The latter values are in agreement with results obtained with 7-month-old (70 kg body weight) ostriches (16). As no values were available for tryptophan, this essential amino acid has been omitted from the calculations.

Results

The maintenance and growth requirements for protein could be calculated as illustrated in Figures 1 and 2. Total absolute protein requirements are presented in Table 3. Although protein requirements are in agreement between genders at young ages, differences in body weight and the general growth pattern resulted in substantial differences between males and females after 3 months of age. Subsequently, amino acid requirements, as illustrated in Table 4, could be calculated.

Table 1. Parameters derived from the Gompertz equation [$C = C_m \times \exp(-\exp(-B \times (t-t^*)))$] for body growth in Greater rheas (13).

Gender	Final mature weight (C_m, g)	Maturing rate constant (B, /day)	Time from hatching (t^*, days)
Male	28706.3	0.01085	136.4
Female	22507.4	0.01212	117.5

Table 2. Essential amino acid composition (g/kg protein) of feather-free empty body and feather protein determined in 1.4-year-old (41 kg body weight) emus (15).

Amino acid	Feather-free empty body	Feathers
Arginine	68.9	68.0
Cystine	11.2	62.9
Histidine	27.1	5.1
Leucine	71.4	100.3
Isoleucine	34.4	43.2
Lysine	73.3	14.3
Methionine	18.3	2.4
Phenylalanine	48.4	46.1
Threonine	40.4	52.4
Tyrosine	30.1	61.8
Valine	40.6	67.0

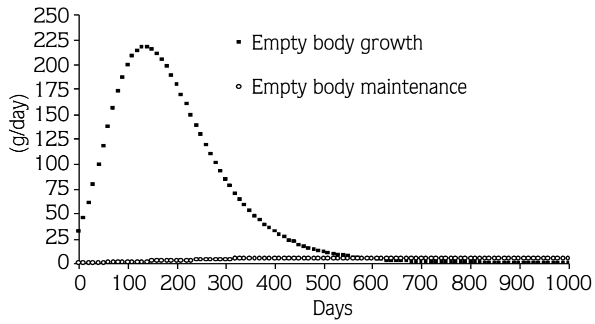

Figure 1. Protein requirements for empty body growth and empty body maintenance of a male Greater rhea.

Table 3. Absolute total protein requirements needed by Greater rheas.

Age (days)	Body weight (g)		Protein requirements (g/day)	
	Male	Female	Male	Female
10	558	568	57.3	57.0
50	2234	2334	148.8	144.5
100	6507	6538	252.6	221.6
200	17,384	15,579	231.2	160.2
300	24,231	20,173	113.3	65.8
500	28,156	22,290	21.8	12.2
750	28,669	22,497	8.8	6.7
1000	28,704	22,507	7.9	6.4

Table 4. Daily amounts (g/day) of essential amino acids needed by a 300-day-old Greater rhea.

Amino acid	Male	Female
Arginine	7.80	4.34
Cystine	1.43	0.84
Histidine	3.00	1.65
Leucine	8.18	4.57
Isoleucine	3.92	2.19
Lysine	8.12	4.47
Methionine	2.02	1.11
Phenylalanine	5.52	3.07
Threonine	4.61	2.58
Tyrosine	3.51	1.98
Valine	4.68	2.63

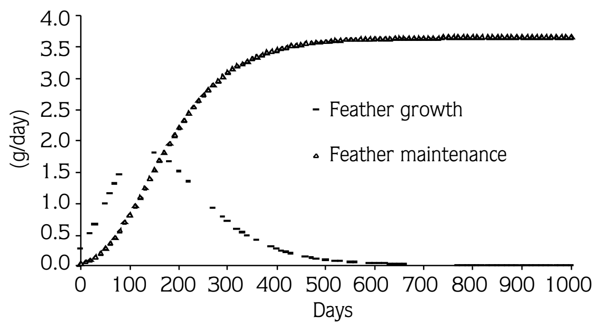

Figure 2. Protein requirements for feather growth and feather maintenance of a male Greater rhea.

Discussion

This study presents evidence that an empirical model, based on growth and developed with domesticated avian species, could be used to estimate protein and amino acid requirements of Greater rheas under captive conditions to achieve maximum production. However, this model has been developed with omnivorous species that have been domesticated for many years on commercial compound diets (17), and does not account for nutritional adaptation strategies of wild birds. Furthermore, theoretical assumptions about maintenance requirements and the conversion of dietary protein and amino acids to body protein were used, and there might be differences in the amino acid patterns of body protein at different ages. Thus, estimations should be regarded as a guideline to possible requirements and serve as a starting point for direct response trials (4,15).

In order to convert absolute requirements to dietary concentrations, thus the minimal percentage of protein or amino acids needed for optimal growth, information on feed intake are needed. The latter information is currently unavailable for Greater rheas, as for most wild birds. Furthermore, the satisfaction of protein and amino acid requirements determined through modelling is complicated in that the actual availability of nutrients within the feed must include allowances for unavoidable losses that occur during digestion, absorption, and metabolism (18). Also, the ability of the gastrointestinal system to modulate its structure and function in reaction to different nutritional regimes needs to be considered.

However, a model has been utilized to estimate the protein and amino acid requirements of the Greater rhea that could be improved and adapted as more information becomes available. This model could also be of value in the evaluation of genetic potential, diets, and general husbandry practices.

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