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Zool. Garten N. F. **73** (2003) 4, S. 238–244
http://www.urbanfischer.de/journals/zoolgart

DER ZOOLOGISCHE GARTEN
Urban & Fischer Verlag

The influence of diet on the body composition of the house cricket (*Acheta domesticus*) and consequences for their use in zoo animal nutrition

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With 3 Tables

Received 27 May 2003

Introduction

House crickets (*Acheta domesticus*) have a growing importance as food. They are used as whole prey food for insectivorous invertebrates and vertebrates, especially for private exotic animals and in zoological gardens. Traditionally, the house cricket has been used as laboratory animal for a long time (Jordan & Baker 1956). For this purpose, systems for mass-production of crickets have been set up. Based on investigations from Ghouri & McFarlane (1958), McFarlane et al. (1959), and Patton (1967) artificial diets for crickets have been designed. The influence of specific nutrients and requirements of crickets have been investigated and published by McFarlane (1964, 1972, 1976 a, 1976 b, 1991, 1992) as well as Meikle & McFarlane (1965).

In feeding trials with chicks (Nakagaki et al. 1987) and with weanling rats (Finke et al. 1989) it has been shown that nutritionally crickets are a high quality protein source. More recently Nakagaki & DeFoliart (1991) have even investigated the mass production of *A. domesticus* as a novelty food for human use.

The use of crickets as food source for non-domestic animals has stimulated studies on the body composition of crickets (Allen & Oftedal 1989, Allen et al. 1993, Barker et al. 1998). These studies examined body composition of house crickets which were raised on different diets or were of different developmental stages. However, to the authors' knowledge no investigation has compared the influence of different diets on body composition of house crickets over a period of a few weeks. This aspect however is of practical importance for zoos and private collectors which do not breed their own crickets but that buy crickets from commercial breeders and keep them alive for a few weeks until being fed. It is of interest to know, if it makes a difference on the nutrient content of crickets if they offer them water only, vegetables or a special cricket diet. In the present study it was therefore decided, to compare the influence of these diets on body composition in house crickets over a period of three weeks.

0044-5169/03/73/04–238 $ 15.00/0

Materials and Methods

Subadult house crickets (average body length 1 cm) were obtained from a commercial operation (Grigfarm, Wittinsburg, Switzerland) and randomly divided in three equally large groups. The animals were kept in three containers (height 42 cm; length 90 cm; width 60 cm) furnished with four cardboard egg dividers, which were changed daily. Room temperature was 25 °Celsius and the average relative humidity was 60%. Group A was offered only water ad libitum, group B only lettuce (*Lactuca sativa*), and group C received a commercial cricket diet (Kliba Mühlen, Kaiseraugst, Switzerland) and water ad libitum. Based on personal observation it is known that in zoos and private collections, crickets are frequently fed with a choice of different vegetables and fruits. Therefore, to copy this situation lettuce was chosen. The reason for using the present commercial cricket diet was that it had been successfully used by breeders in Switzerland. Upon receipt (= day 0) and on day 7, 14, and 21 samples of crickets were collected from each group. The samples were immediately frozen at minus 20 °Celsius and subsequently freeze-dried to constant weight. Before analysis, the dried crickets were ground to a particle size of approximately 1 mm with a coffee grinder.

From these samples water, ash, fat, crude fibre, gross energy (GE), calcium, phosphorus, vitamin A, and vitamin E contents were analysed. It was decided not to calculate the crude protein content but instead to give the value for total nitrogen (Total-N). The reason for this was, that crickets, like most invertebrates contain large amounts of non-protein nitrogen, which is found in the chitin (amino-cellulose). Moisture content was determined by calculation of the difference of weight before and after freeze drying. The contents for ash, total nitrogen, fat, and crude fibre were determined using standard procedures for Weender analysis. The phosphorus concentrations were measured with an autoanalyzer (Cobas Mira, Roche, Basle, Switzerland) with a colorimetric method. The calcium concentrations were measured by atomic absorption spectrometry (SpectrAA-20, Varian, Zug, Switzerland). All these analysis were performed at the Swiss Federal Research Station for Animal Production in Posieux (an ISO certified laboratory).

Vitamin A and vitamin E were quantified by high pressure liquid chromatography (HPLC) as described by Manz & Philipp (1988 a and b). Gross energy was determined by bomb calorimeter.

Results are presented throughout as absolute values or as means ± standard deviation (SD) and n is the number samples. Data was subjected to a one way analysis of variance (ANOVA). A probability of $P < 0.05$ was accepted as level of significance.

Results

Table 1 gives the nutritional values of the lettuce and the cricket diet offered to Group B and Group C, respectively. Fresh matter weight of the cricket samples averaged 247 g (± 58.7; n = 10). Tables 2 and 3 summarize the results for the contents of water, ash, fat, crude fibre, total-N, GE, vitamin A, vitamin E, calcium, and phosphorus. Statistical analysis did not produce significant differences between nutrient concentrations in groups A, B, and C.

Table 1. Nutritional analysis of lettuce (*Lactuca sativa*) and of a commercial cricket diet (Kliba Mühlen, Kaiseraugst, Switzerland)

Nutrient	Commercial cricket diet[a]	Lettuce[b]
Water (%)	9.2	95
Ash (g/kg DM)	65	144
Protein (g/kg DM)	235	250
Fiber (g/kg DM)	43	110
Fat (g/kg DM)	54	44
Gross energy (MJ/kg DM)	19	2.6
Vitamin A (IU/kg DM)	21 620	–
Beta-Carotene (mg/kg DM)	–	158
Vitamin E (mg/kg DM)	130	80
Calcium (g/kg DM)	9.1	7.4
Phosphorus (g/kg DM)	7.9	6.6

[a] Source: analysis at the Swiss Federal Research Station for Animal Production
[b] Source: Souci et al. (1989)

Table 2. Nutritional analyses of house crickets (*Acheta domesticus*) fed different diets over a period of three weeks. Group A received ad libitum water only, group B lettuce (*Lactuca sativa*) and group C a commercial cricket diet

Group	Day	Water (%)	Ash (g/kg DM)	Total-Nitrogen (g/kg DM)	Fiber (g/kg DM)	Fat (g/kg DM)	Gross Energy (MJ/kg DM)
	0	67.7	35	90	69	356	28.4
A	7	70.3	37	96	68	333	27.6
	14	71.7	42	104	81	266	26.7
	21	73.0	74	112	98	192	25.1
B	7	69.9	37	95	68	334	27.7
	14	72.0	76	103	82	247	26.2
	21	73.9	56	110	91	176	25.2
C	7	68.5	36	91	55	331	27.6
	14	67.3	40	91	64	296	26.8
	21	67.1	49	96	74	234	26.8

The average water content of crickets was 70% (±2.5; n = 10), which is exactly what Clifford & Woodring (1990) found. There was a reduction of fat and an increase of total-N and fibre content during the study period in all three groups. The reduction of fat content resulted in a reduction of GE. The fibre and total-N content rose more in groups A and B than in Group C.

Variations were noted in the vitamin A content of crickets within the groups and over time. Crickets in group C had the highest vitamin A concentration. Vitamin E concentrations decreased in all three groups. For the calcium concentration, an increase was only noted in group C over the three weeks period, whereas phosphorus levels increased in all three groups.

Table 3. Contents of vitamin A and E, calcium and phosphorus in house crickets (*Acheta domesticus*) fed different diets over a period of three weeks. Group A received ad libitum water only, group B lettuce (*Lactuca sativa*) and group C a commercial cricket diet

Group	Day	Vitamin A (IU/kg DM)	Vitamin E (mg/kg DM)	Calcium (g/kg DM)	Phosphorus (g/kg DM)
	0	420	31	1.0	6.5
A	7	390	14	< 1.0	6.7
	14	380	12	< 1.0	7.7
	21	430	12	< 1.0	7.7
B	7	370	16	< 1.0	6.7
	14	600	11	< 1.0	7.4
	21	590	8	< 1.0	8.4
C	7	570	24	< 1.0	7.0
	14	1 220	15	1.3	7.5
	21	750	13	1.2	7.1

Discussion

The aim of the present study was to compare the influence of three different diets on the body composition of house crickets over a three week period. No significant differences between the three groups were detected.

In all three groups the fat content of crickets decreased with time. This observed decrease is interesting. In mammals and birds it is known that with age the body fat content increases. The most likely explanation for the decrease in fat content is that the crickets received from the breeder were exceedingly fat. The animals in this study had a fat content 356 g/kg DM. Comparison with own data of crickets from five different breeders (HATT, unpublished) as well as published data from BARKER et al. (1998) suggest that a crude fat concentration of about 200 to 250 g/kg DM may be considered normal. It would have been of interest to analyse the diet fed at the breeder, however such a food sample could not be obtained.

In all three groups the nitrogen content did increase. The explanation for this, is most probably an increase in the chitin content. Chitin (amino-cellulose) constitutes the major part of the exoskeleton of insects. Further studies should asses the influence of diet and age in relation to the chitin content of crickets.

In Table 3 it appears that the commercial diet had an impact on the vitamin A levels of the crickets. However the values in group C were not significantly different from group A and B. Furthermore vitamin A levels in house crickets may be subjected to considerable variations. This was also observed in other analyses of crickets (HATT, unpublished) and data published by BARKER et al. (1998). The same is true for the vitamin E levels which did not show a significant trend.

The calcium and phosphorus content were not influenced at a significant level by the diets used in this study. All analysed crickets, including those obtained directly from the breeder had a negative Ca : P ratio. Due to their influence on metabolic bone disease these minerals have been given special attention with crickets used as whole prey feed in reptiles. The fact that crickets are a poor source of calcium is well

known and it has been recommended that crickets be fed on high calcium diets to increase their value (Allen et al. 1993). However, when analysing the calcium concentration of crickets it should be emphasised, that it seems likely that gut content may influence the value. This was already proposed by Bilby & Widdowson (1971), trying to explain how altricial birds can develop a healthy skeleton when fed with invertebrates, which generally are low in calcium.

In conclusion the present study shows that in subadult house crickets over a three week period the diet did not have a significant influence on body condition. Therefore, based on our results there was no difference in body quality if crickets were offered only water, lettuce or a commercial cricket diet. Considering that a calcium and phosphorus imbalance currently is of major clinical importance in animals fed on crickets our findings support the current practice in zoo animal nutrition to improve the nutritional value of crickets by dusting with a mineral and vitamin supplement before being offered as whole prey food. This technique has proven to be both a practical and effective method to surpass the nutrient deficiencies in body composition of house crickets.

Acknowledgements

This study was undertaken with a grant from the "Jubiläumsspende" of the University of Zurich. The authors would like to thank Mr. P. Hofmann of the company Hofmann-La Roche in Basel for performing the vitamin analyses and Mr. C. Chaubert from the Swiss Federal Research Station for Animal Production in Posieux for all the chemical analyses. We would also like to acknowledge Mr. A. Fairburn for the technical support with the freeze-drying and Mr. E. Eggenberger for the statistical date processing.

Summary

The present study was conducted to evaluate the influence of diet on selected aspects of body composition of house crickets (*Acheta domesticus*) over a three weeks period. Subadult crickets were purchased from a commercial breeder, randomly divided in three groups, and kept under identical conditions except for the diet. Group A received ad libitum only water, Group B lettuce (*Lactuca sativa*), and Group C a commercial cricket diet. On day 0, 7, 14, and 21 samples of each group were collected and analysed for water, total nitrogen, fibre, ash, fat, gross energy, vitamin A, vitamin E, calcium, and phosphorus content. There were no significant differences in the values analysed between the three groups. It is concluded that in subadult crickets over a three week period the diet does not appear to have a significant impact on the body composition and possibly the nutritional value of crickets used as whole prey food. Based on the analyses the importance of improving the nutritional content of crickets with a vitamin and mineral supplement is discussed.

Zusammenfassung

In der vorliegenden Studie wurde der Einfluß der Ernährung auf die Nährstoffzusammensetzung bei Heimchen (*Acheta domesticus*) über einen Zeitraum von drei Wochen untersucht. Subadulte Heimchen wurden von einem Züchter bezogen und in drei Gruppen aufgeteilt, die

sich nur in der Fütterung unterschieden. Gruppe A erhielt ad libitum nur Wasser, Gruppe B Kopfsalat (*Lactuca sativa)* und Gruppe C ein Grillenzuchtfutter. Am Tag 0, 7, 14 und 21 wurden Proben auf folgende Nährstoffe untersucht: Wasser, Stickstoff, Rohfaser, Rohfett, Rohasche, Bruttoenergie, Vitamin A, Vitamin E, Kalzium, und Phosphor. In dem untersuchten Zeitraum von drei Wochen zeigte sich, daß die Fütterung der Heimchen keinen signifikanten Einfluß auf die Nährstoffzusammensetzung gehabt hat. Diese Beobachtung ist von Bedeutung, da Heimchen in der Zootierernährung häufig eingesetzt werden und Möglichkeiten der Supplementierung werden diskutiert.

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