Food Consumption and Growth of Juvenile Chinese Soft-shelled Turtles (*Pelodiscus sinensis*) in Relation to Body Weight and Water Temperature

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Abstract.- Food consumption and growth of juvenile Chinese soft-shelled turtles (*Pelodiscus sinensis*) with different body weight were measured in the laboratory at 22, 26, 28, 30, 32 and 35 °C. At 30 °C, the daily maximum consumption C_{max} (J/ind. · day) showed the following relationship with body weight W (g): $C_{max} = 47.58\ W^{0.7907}$. The correlation between the maximum daily food consumption rate R_{max} (J/g · day) of a turtle with a standard body weight of 40 g, and temperature could be described as: $\log R_{max} = -0.0136T^2 + 0.8372T - 11.42$. At ± 31 °C, a turtle with a standard body weight of 40 g has the biggest daily consumption rate of 447 J/g · day. The daily growth rate GR (g/day) had a functional relationship with body weight at 30 °C: $GR = 0.04W^{0.8248}$. For a turtle with a standard body weight of 40 g, GR showed the following relationship with water temperature: $GR = 30.138 - 3.671T + 0.147T^2 - 0.002T^3$, and at 30 °C, turtles had the biggest daily growth rate of 1.06 g/day. Gross conversion rate of the juvenile turtles (9–109 g) did not vary with body weight, but temperature had a distinct effect on it.

Key words.- Reptilia, Testudines, Trionychidae, *Pelodiscus*, China, bioenergetics.

Introduction

The Chinese soft-shelled turtle (*Pelodiscus sinensis*) is an aquatic chelonian of great commercial importance, widely distributed in China. Resource of this species has decreased sharply in recent years. Therefore, its aquaculture has become more and more important. Basic information on the biology of *P. sinensis* is very important in developing the technology of its cultivation. Bioenergetics of this species is one aspect that has not been well-studied yet (Niu et al. 1994). The purpose of this study was to investigate the effects of body weight and water temperature on food consumption and growth of juvenile soft-shelled turtles.

Material and Methods

The experimental animals were juveniles with a live weight ranging from 7 g to 112 g reared in the laboratory. The diet used in the experiment contained 50% crude protein, 3% crude fat, 9.5% carbohydrate and 15% ash. Energy value of the diet was 14.64 KJ/g.

Rearing conditions

Each experimental animal was housed in a 4.6 l glass aquarium filled with clean tap water. 6–8 aquariums were placed in a water bath with water temperature controlled to an accuracy of ± 0.5 °C. The animals were tested at six different temperatures (22, 26, 28, 30, 32 and 35 °C). The photoperiod was 12L:12D. Turtles were fed to satiation twice a day at 8:00 and 16:00. Each turtle was acclimated at the test temperature for at least one week before the feeding experiment started.

Experimental process

Before the start of the feeding experiment, turtles were not offered food for 48 hours and weighted. In the experiment, turtles were fed to satiation with a pre-weighted amount of food. The uneaten portion and feces were collected with a decompression concentrition equipment and dried with control diet at 65 °C to a constant weight. Food consumed by a turtle was the difference between the dry weight of pre-weighed amount of food and the uneaten portion. The feeding regime lasted for a month followed by two days of fasting. After the experiment, fresh weight was measured again and some of the experimental animals were sacrificed and dried to a constant weight on 65 °C. Caloric value of the dried diets, feces, and turtles were all measured with a Schimdzu CA-4P caloric meter.

Data analysis

The daily maximum consumption, C_{max} is an average value during the whole experimental period. $R_{max} = C_{max}/W$. W is the mean value of the initial and final weight of the turtle. The daily growth rate in wet

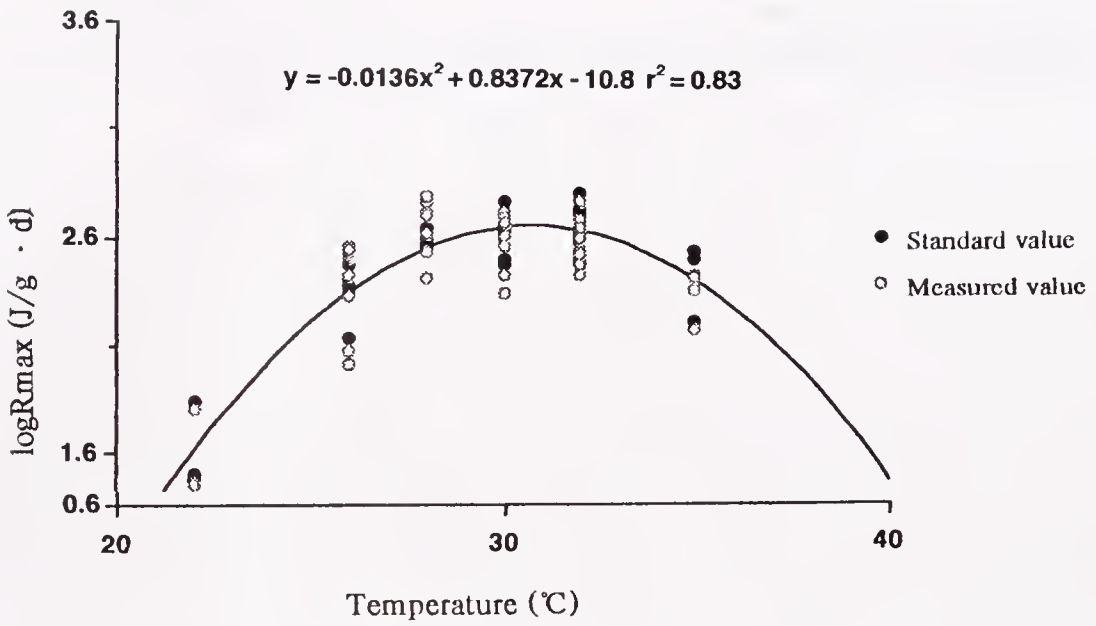

Figure 1. Relationship between the daily maximum consumption rate, R_{max} (J/g · day) of a turtle with a standard body weight of 40 g (average value of all experimental animals) and water temperature.

weight, GR = $(W_t - W_0)/t$, where W_t and W_0 is the body weight at the end and the beginning of the experiment, respectively, and t is the experimental period. The gross conversion efficiency, CE — named as the percent of energy used for body growth to consumed energy — was calculated. All data were analysed with SPSS/PC statistical software.

Results

Analysis of covariance showed that the maximum food consumption of a turtle was greatly affected by body weight and water temperature. Multiple regression analysis showed the following relationships among the daily maximum consumption, C_{max} (J/ind.· day), wet body weight, W (g) and water temperature, T (°C): $\log C_{max} = 0.7338\log W + 0.8354\log T - 0.0136T^2 - 11.00$; ($r^2 = 0.98$, n = 45, P < 0.01). At 30 °C, C_{max} (J/ind.· day) showed the following relationship with body weight W (g): $C_{max} = 47.58W^{0.7907}$; ($r^2 = 0.92$, n = 30).

Figure 1 shows the relationship between the daily maximum consumption rate, R_{max} (J/g · day) of a turtle with a standard body weight of 40 g (average value of all experimental animals) and water temperature. Their relationship could be described as: $\log R_{max} = -0.0136T^2 + 0.8372T - 11.42$ ($r^2 = 0.83$, n = 45). At ± 31 °C, a turtle with a standard body weight of 40 g has the biggest daily food consumption rate of 447 J/g · day. The daily growth rate, GR (g/day) also had a close relationship with body weight and water temperature, which could be showed as the following: $GR = 0.0165W + 0.9142T - 0.0156T^2 - 13.16$ ($r^2 = 0.89$, n = 45, P < 0.01).

Figure 2 shows the relationship between the daily growth rate, GR (g/day) of a turtle with a standard body weight of 40 g and water temperature. At 30 °C, a turtle with a standard body weight of 40 g has the biggest daily growth rate of 1.06 g/day. At 30 °C, GR had a functional relationship with body weight as: $GR = 0.04W^{0.8248}$ ($r^2 = 0.78$, n = 39). At five different body weight groups ranging from 9–109 g, no distinct differences were found among their gross conversion efficiency, CE ($F_{4,20} = 0.96$, P > 0.05), but the temperature had a distinct influence on CE ($F_{5,20} = 4.21$, P < 0.01). At 22 °C, CE was about 59%. At 26–32 °C, CE ranged from 21–27%. At 35 °C, CE declined to 12%.

Discussion

According to the present work, temperature has a positive effect on the daily maximum food consumption and growth under 31 °C, but above 31 °C, the effect becomes negative. Temperature for maximum growth rate is slightly lower than the temperature for maximum food consumption. This phenomenon has also been observed in similar studies of the lizards *Uta*

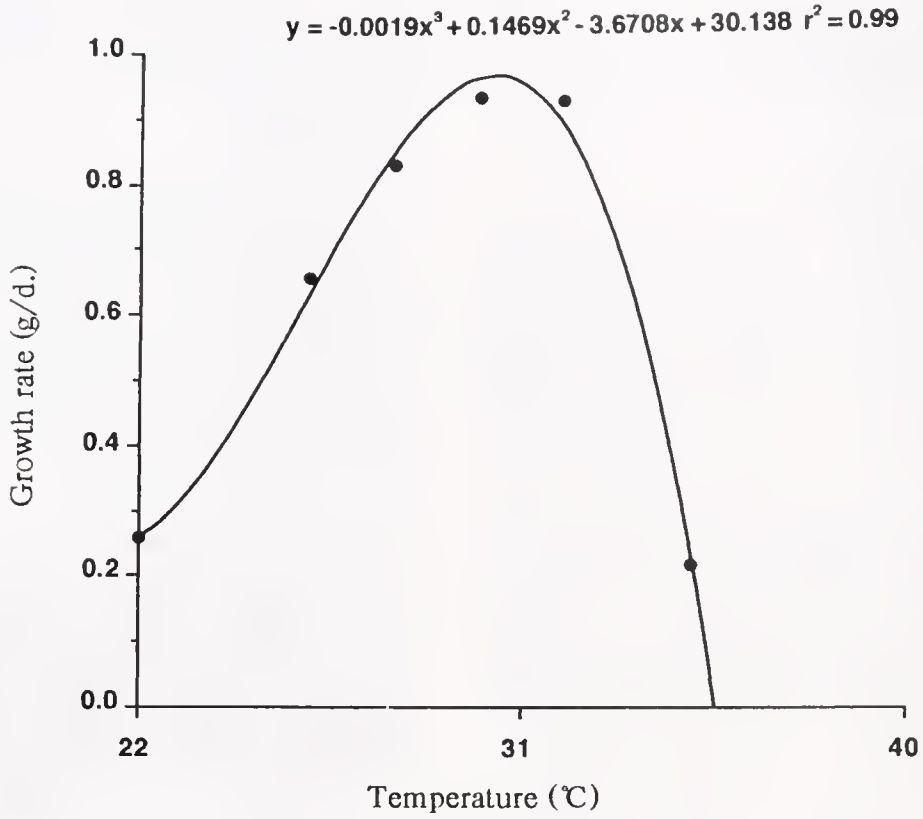

Figure 2. Relationship between the daily growth rate, GR (g/day) of a turtle with a standard body weight of 40 g and water temperature.

stansburiana (Waldschmidt et al. 1986) and *Takydromus septentrionalis* (Ji et al. 1993), and the southern catfish (*Silurus meridionalis*) (Xie and Sun 1992). This study indicates that effects of temperature on food consumption and growth of soft-shelled turtles resemble that of most fishes (Brett and Groves 1979) and some lizards. More comparative studies should be conducted for other reptile species.

The body weight has a double logarithm relationship with C_{max}, and the slope of the regression line is 0.79. This value is very similar to the exponent b value 0.75 in the metabolic rate to body weight regression line for turtles (Bennett and Dawson 1976). This phenomenon suggests that food consumption is related to metabolic rate of the turtle. As energy loss through metabolism is a large component in the energy budget, metabolism level may affect energy intake to remain an effective budget. Studies on the relationship of food consumption and metabolic rate are recommended. Perhaps the maximum consumption rate can be defined as an index of daily metabolism level of the animals.

The gross conversion rate, CE is a reflection of the consumed energy alloted to body growth. Our work showed that under 109 g body weight, CE values of the juvenile turtles were similar. Temperature has a distinct effect on CE. The relatively high CE (59%) at 22 °C may be explained by the distinctly low metabolic cost at a low temperature. From 26–32 °C, CE was relatively similar, but declined at 35 °C. Smith et al. (1981) found that for juvenile walleye pollock (*Theragra chalcogramma*), CE was higher at colder temperatures. Cui et al. (1995) showed that water temperature had no effect on CE in the grass carp (*Ctenopharyngodon idella*). Perhaps the relationship of temperature with CE varies with different species.

In this work we present mathematical models relating maximum food consumption and growth rate to water temperature and body weight. The results can be utilized for estimating daily amount of food needed by juvenile turtles according to water temperature and body weight in a turtle-culture farm.

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