Sex determination of green turtle, *Chelonia mydas*, related with nest temperature

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Abstract We could find a seasonal change of sex ratio with an air temperature by examining sex of 443 dead bodies among hatchlings of green turtle, *Chelonia mydas*, collected from October 1998 to October 1999 on the Khram Island, Thailand. A percent female was under 50% at an air temperature below about 28 ℃. Sand temperatures beside three nests were recorded by data loggers. As compared with indexes among Yntema (1979), Mtasuzawa (1998) and our two ideas, we proposed our index as a reference incubation temperature, because of easy calculating the index and having a hatching process to differentiate into each sex. The index is an average daily sand temperature in a period from nesting day to the metabolic heating day. Effect of shade by a plastic net over four nests to a percent female was examined. A percent female (30-100%) under shade was lower than that (100%) under sunshine.

Keywords: green turtle, data logger, sex ratio, TSD, reference incubation temperature, shading effect

Introduction

It is well known that the incubation temperature does not influence only both on incubation period and hatching rate, but also on hatchling sex ratio (Mrosovsky,1994; Ackerman,1997). Matsuzawa (1998) proposed his empirical model which was able to estimate both a female and a male hatchling number by following data; time series data of sand temperature, daily numbers of new egg-laying nests and a clutch size for the loggerhead sea turtle, *Caretta caretta*. It is most important to record temperature data in sand beside a nest and also to find a functional relationship between hatchling sex ratio and sand temperature in his model.

We planed to apply his idea to estimate both a female and a male hatchling number for the green sea turtle, *Chelonia mydas*, in Thailand. However, we had no information on temperature-dependent sex determination (TSD) for the green turtle in the field. In this paper, we introduce our preliminary results on hatchling sex ratio of green turtle related with nest temperature by a data logger from 1999 to 2000 on the Khram Island.

Seasonal changes of hatchling sex ratio

Sex of 443 dead bodies among hatchlings collected from October 1998 to October 1999 on the Khram Island were identified by a histological method. A percent female in 12 months was 65.5% in average. This percent female changed seasonally as a highest percent female was 87% in August nesting and lowest 45.5% in October (Fig.1). A relationship between this percent female and an average air temperature at next month after nesting was shown in Fig.2. The highest air temperature was 29.9 ℃ at March 1999 and the lowest 26.3 ℃ at December 1998. The difference of temperature was only 3.6 throughout the year. A percent female was under 50% at an air temperature below about 28 ℃. We may consider that pivotal value for sex differentiation in green turtle is in roughly 28 ℃ as based air temperature.

We could find out what a hatchling sex ratio on green turtle was dependent of an air temperature in the case of Thailand.

Hatchling sex ratio related sand temperature

Sand temperatures were recorded in sand beside three nests on the Khram Island from May to July, 1999, by a data logger of temperature (Fig. 3). The clutch size in each nest was 89, 90 and 112, respectively (Tab.1). Sex of hatchling was examined by a histlogical method. The range of percent female was 40% to 60%. A reference incubation temperature should be decided to look for relationship between sex retio and nest temperature. The sensitive period for the effect of temperature on sexual differentiation appears to occur around in the middle third of incubation temperature under the constant temperature condition (Yntema,1979; Yntema and Mrosovsky,1982). We could find that metabolic heating arose from hatching also occurs in this period by data logger (Fig.3). Matsuzawa (1998) used a data logger to measure sand temperature beside nest. He proposed an average daily sand temperature in a period between 192.9 ℃ and 262.7 ℃ of integrated sand temperature over 19.8 ℃ day by day as this incubation temperature. However, we could not understand his integrated temperature to TSD. And also it was difficult to find or calculate exact integrated temperature value proposed by him. Then we thought out two indices to a reference incubation temperature. One of them is an average daily sand temperature in two weeks after the day when metabolic heating occurred. But, we could not find the metabolic heating day in some cases. Second index is an average daily sand temperature in a period from nesting day to the metabolic heating day. When we could not find the metabolic heating day, we used an average sand temperature in three weeks since nesting day as this index. These four reference incubation temperatures are listed in Tab.1.

It was suggested that a percent female may become higher as a reference incubation temperature becomes warmer in all cases. As compared with these indexes, we want to propose our second index as a reference incubation temperature on the grounds that it is easy to calculate the index and the period may have a hatching process to differentiate into each sex.

Effect of shade over a nest to a percent female

Effect of shade by a plastic net over four nests to a percent female was examined on the Khram Island from May to September, 2000. We set a data logger in the center of nest on this experiment. An average nest temperature under a shade condition was lower than that under sunshine as a control condition (Fig.4). Number of days (49-53days) for hatching under shade may be longer as comparing with that (46-47days) under sunshine with a warmer incubation temperature. A percent female (30-100%) under shade was lower than that (100%) under sunshine.

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Table 1 Parameters on hatching process, sand temperatures and reference incubation temperatures on three nests on the Khram Island from May to July, 1999, Thailand.

	Name of Nest		
	No.1	**No.2**	**No.3**
1. Parameters on hatching process			
clutch size (NO. of egg)	89	90	112
hatching rate (%)	78.7	84.4	73.2
emergence rate (%)	100	100	100
% female	60	50	40
2. Sand temperature (℃)			
range	29.38-31.89	29.16-32.17	28.86-31.05
average	31.65	30.95	30.50
3. Reference incubation temperature (℃)			
Yntema (1982)	31.30	30.11	29.79
Matsuzawa (1999)	30.76	29.84	30.17
this study-index 1	31.39	30.09	30.66
this study-index 2	30.40	29.50	29.28

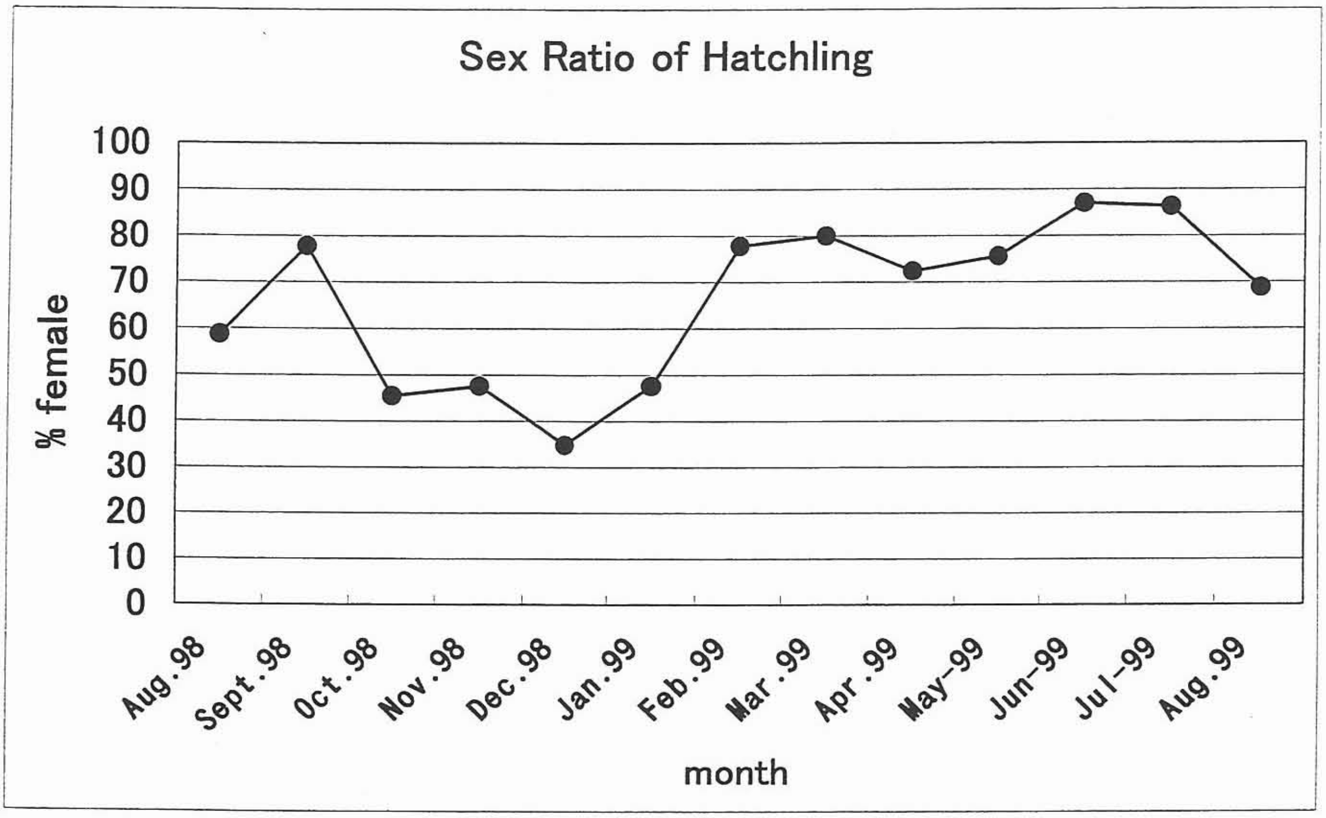

Fig.1 Seasonal change of sex ratio (% female) of green turtle hatching from August 1999 on the Khram Island Thailand.

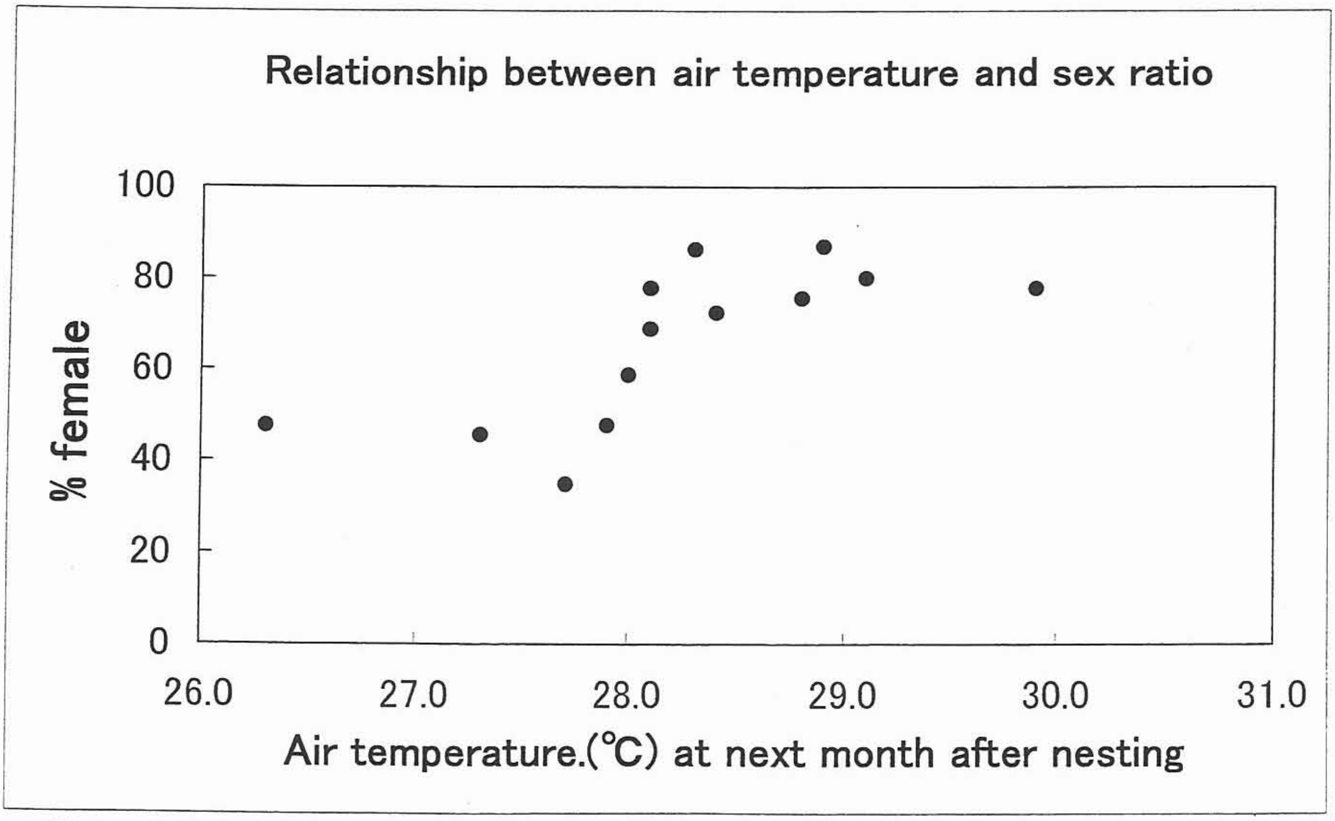

Fig.2 Relationship between air temperature (℃) at next month after nesting and sex ratio (% female) of green turtle hatching in the Khram Island.

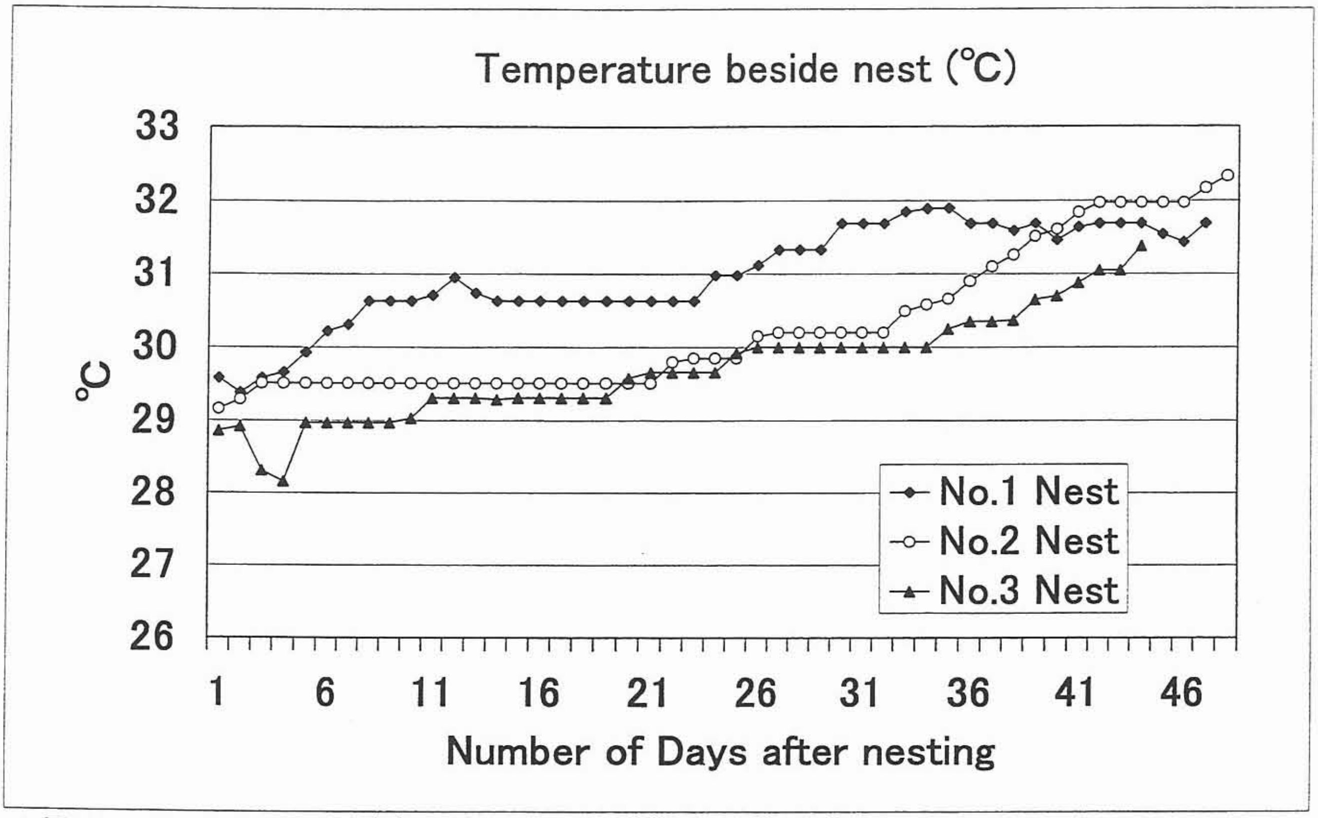

Fig.3 Snad temperature (℃) beside nest by a data logger on the Khram Island.

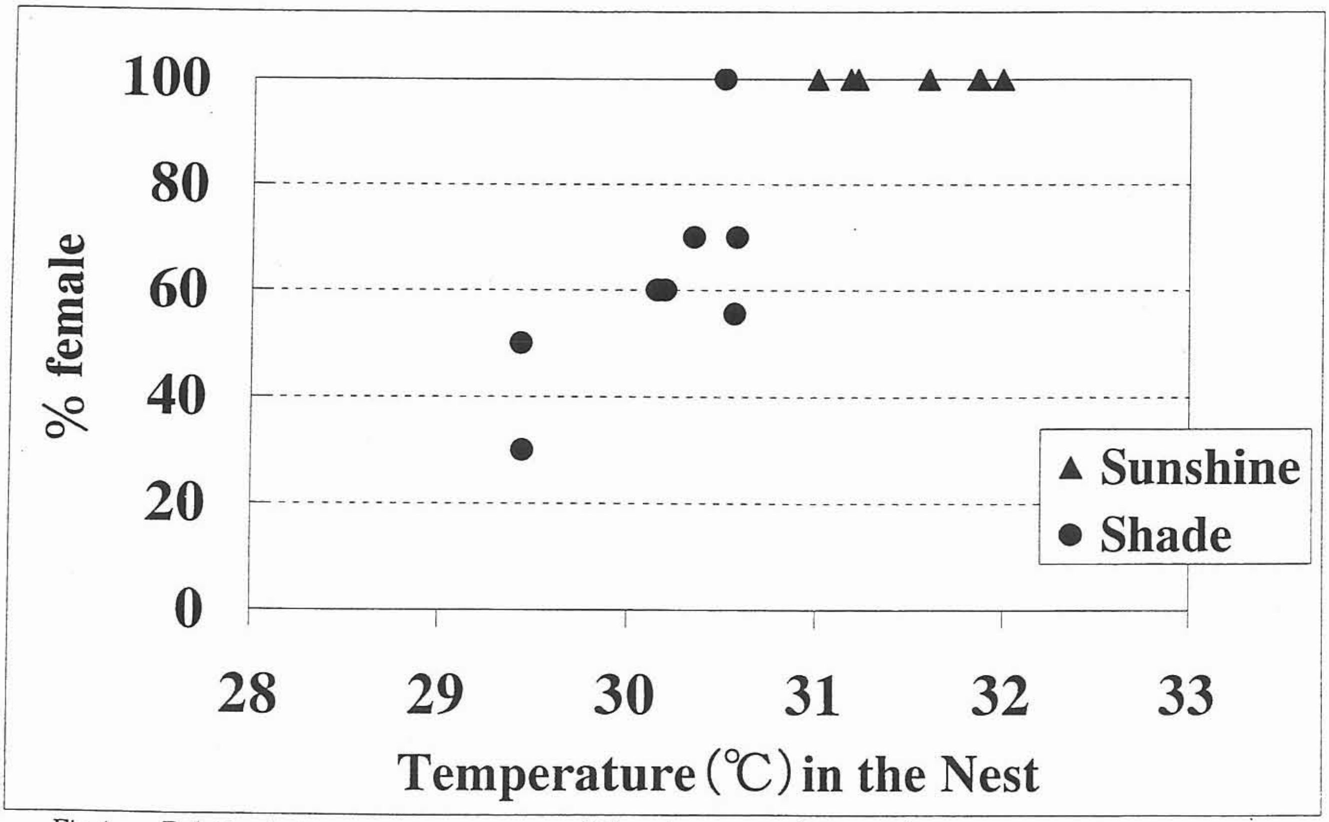

Fig.4 Relation between nest temperature (℃) and sex ratio (% female) of green turtle hatching under shade or sunshine condition