Chapter 7

Captive Breeding of the Siamese Narrow-headed Softshell Turtle *Chitra chitra* Nutphand, 1986 (Testudines: Trionychidae)

Abstract

A captive breeding program of a critically endangered species, the Siamese narrow-headed softshell turtle *Chitra chitra* Nutphand, 1986, was conducted in two 400 m^2 ponds at Kanchanaburi Inland Fisheries Research and Development Center (KIFRDC), Kanchanaburi Province, Thailand from 2000 to 2002. Copulations were observed during September to February. Two females laid eggs during February to April in artificial sandbanks. Each captive female produced 3 or 4 clutches/year with 40-88 eggs/clutch. Egg sizes (n=220) were 31.94±1.57 mm in width (range 26.89-34.37 mm), 33.16±1.54 mm in length (range 29.39-40.49 mm) and 19.00±1.67 g in weight (range 15.31-21.60 g). The mean incubation time of *C. chitra* eggs was 59±3 days (n = 255) with a range of 55-65 days at 24-42 $^{\circ}C$ air temperature and 24-39 $^{\circ}C$ sand temperature. Hatchling sizes (n=297) were 38.46±1.52 mm in carapace width (range 32.00-41.67 mm), 42.97±1.59 mm in carapace length (range 36.27-46.66 mm) and 13.10±1.03 g in weight (range 9.09-14.89 g). The hatching success in each clutch varied from 3 to 94 %. The hatchlings were fed with fry fishes of *Labeo rohita* and *Oreochromis niloticus*. After 14 weeks, mean hatchling size was 86.70±5.17 mm carapace width, 91.72±5.75 mm carapace length and 103.97±18.08 g weight, respectively. The survival rate of juveniles was 90.64%.

Key words: *Chitra chitra*, softshell turtle, captive breeding, incubation, growth

Introduction

The Siamese narrow-headed softshell turtle, Chitra chitra Nutphand, 1986, is found in Thailand, Malaysia, and Indonesia (Thirakhupt and van Dijk, 1994; Engstrom et al., 2002; Kitimasak and Thirakhupt, 2002; McCord and Pritchard, 2002). It is probably the largest softshell and freshwater turtle in the world (Pritchard, 2001). All populations of this species are declining, and it is considered very rare in all these countries. IUCN (2000) listed its status as "critically endangered" due to its extremely high risk of extinction in the world. The causes of its decline are due mainly to the reduction of suitable habitat resulting from dam construction and other human-related habitat alterations, and from exploitation for food and the animal trade (Thirakhupt and van Dijk, 1994).

Moll and Moll (2000) stated that captive breeding programs may be an important conservation and management methods which can be used to conserve riverine turtles under certain circumstances – especially when suitable natural habitat remains for the release of hatchlings or head-started juveniles produced by this methodology. Unfortunately the opportunity to apply this approach toward C. chitra's conservation and return toward healthier population sizes in nature has been hampered by our inadequate knowledge concerning its basic biological requirements, and consequently, of the most effective techniques for successful maintenance and breeding of captives. This study was conducted to provide data which will alleviate these deficiencies, and therefore provide a sound protocol for successful captive maintenance and breeding of adult C. chitra, and the maintenance and growth of hatchling C. chitra to a size which is deemed most suitable for release into natural habitats.

Materials and Methods

Six Chitra chitra, two females and four males, were maintained in two outdoor enclosures at Kanchanaburi Inland Fisheries Research and Development Center (KIFRDC), Tha Moung District, Kanchanaburi Province, Thailand. The breeding ponds, 400 square-meter (16x25 m), were constructed near the Mae Klong River and were climatically similar to the natural habitat. The water depth varied from 60 to 80 cm, and a 30 m^2 artificial sandbank ascending 80-90 cm above water level was constructed for nesting in each enclosure. Roofs were constructed over the sandbanks for protection from rain-induced mortality of eggs and hatchlings (Kraemer and Bell, 1980). Fences were also constructed around the ponds to protect turtles and their eggs from predators, such as dogs, snakes, and monitor lizards (Figure 7.1). A female and two males were placed in each pond (Table 7.1). Foods provided for C. chitra in the captive ponds were mainly live Nile tilapia Oreochromis niloticus; native fishes, such as Bardodes gonionotus, were available, entering the ponds during water exchange with the Mae Klong River daily Monday – Friday. Air and water temperature in the captive ponds were recorded throughout the year (Figure 7.2).

Pond A

Pond A was completed in early 2000. The first female, 111 kg, was released on 26 February 2000. It was captured from the Kwae Noi River, Kanchanaburi Province, in 1997 and was separated from males for three years. The first male, 44 kg, was captured from the Mae Ping River, Nakhon Sawan Province, in June 1998. It was released in the breeding pond on 31 March 2000. The second male, 60 kg, was captured from the Kwae Noi River in April 1999 and was released into this pond on 2 November 2000.

Pond B

Pond B was completed in November 2001. One female, 71 kg, and a male, 88 kg, were caught from the Mae Klong River system in 1997. The second male, 88 kg, was caught from the agricultural canal (joining the Mae Klong River and the Tha Chin River) in Nakhon Pathom Province on 3 May 1999. All of them were released in the Pond B in November 2001.

Figure 7.1 Chitra chitra rearing Pond A at Kanchanaburi Inland Fisheries Research and Development Center.

Terrestrial Activity and Breeding Behavior

Terrestrial activity and breeding behavior of C. chitra in the breeding ponds were monitored through the year. Terrestrial activity was nocturnal, and its occurrence and frequency data derived from tracks in the sand. Walking tracks indicated terrestrial movement without nesting activity. The track dimensions allowed identification of the individual(s). Nest tracks led to

blank nests or nests with eggs. Mating behavior and copulation duration were also observed and recorded.

Table 7.1 Size, locality, date of capture, and date of release into breeding pond of C. chitra in captivity.

Pond	Sex	Shell length (cm)	Shell width (cm)	Weight (kg)	Locality (river)	Capture time	Released time
A	Female	98.5	81	111	Kwae Noi	1997	26/2/2000
	Male 1	76	66	44	Mae Ping	6/1998	31/3/2000
	Male 2	82	70	60	Kwae Noi	4/1999	2/11/2000
B	Female	84	75.5	61	Kwae Noi	1997	19/11/2001
	Male 1	97	85	88	Kwae Noi	1997	19/11/2001
	Male 2	103	85	88	Mae Klong river system	5/1999	11/2001

Incubation methods

Nests were excavated by hand within 48 hours after nesting. When the first egg was uncovered, the depth to the top of the egg chamber was measured. The depth to the bottom and the width of the chamber were also measured. Eggs of the first and the second clutch of each breeding pond were weighed to the nearest 0.01 g with an electronic balance and linear measurements of width and length measured to the nearest 0.01 mm with digital calipers. The number of eggs and clutches of each female were recorded.

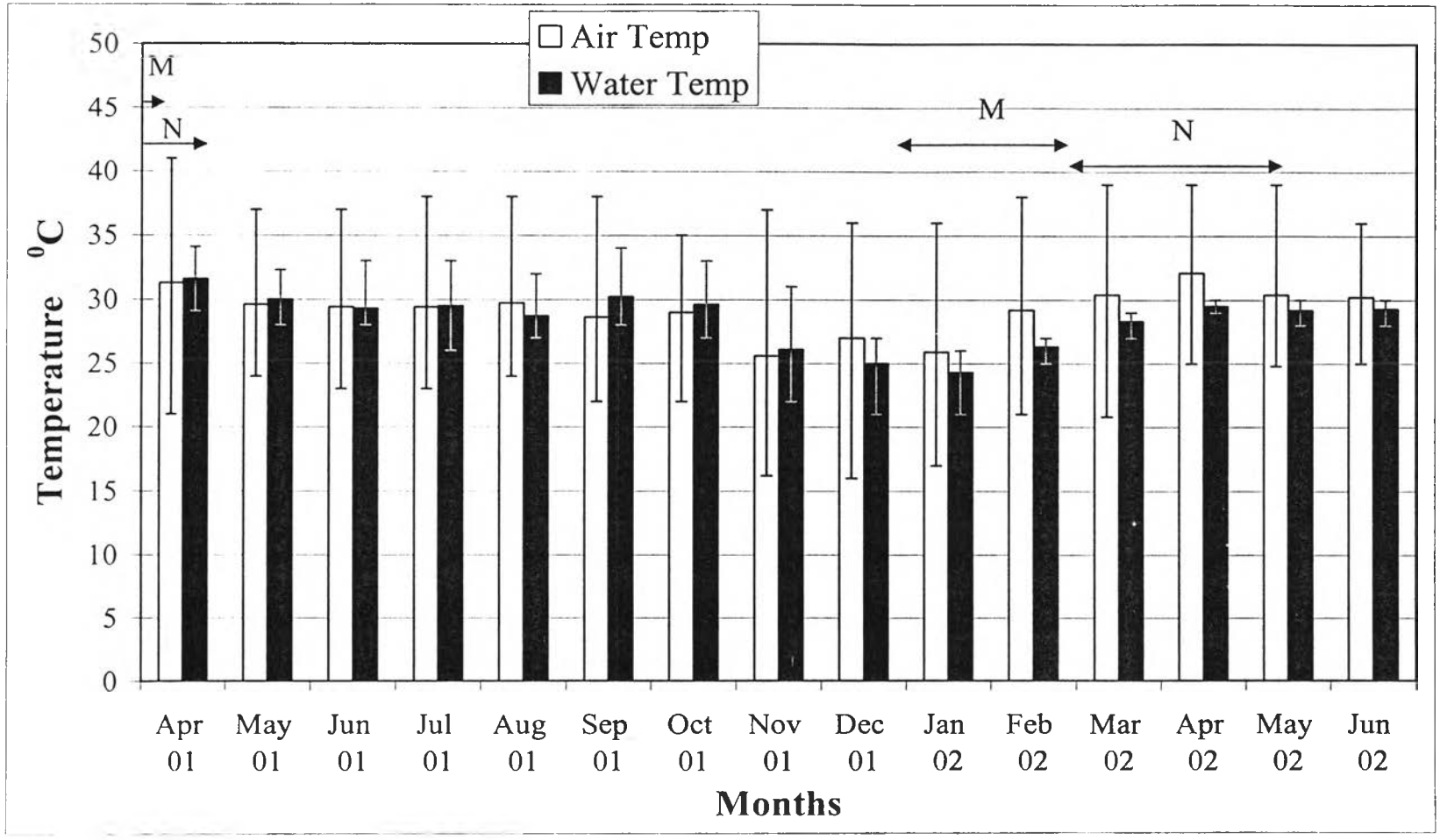

Figure 7.2 Means of water and air temperature in pond A during April 2001 to June 2002. The vertical bars show maximum and minimum of air temperature and water temperature in each month. The arrows show periods of mating (M) and nesting (N).

The eggs were carefully removed and handled to prevent horizontal rotation and reorientation of their vertical axes. Three methods were used for incubation. In the first method, one clutch from each pond was transported to the Department of Biology, Faculty of Science, Chulalongkorn University.

Eggs were put in a plastic container, 40x70x37 cm^3, on 10 cm thick of sand and were covered with 20 cm of additional sand. Moisture in the container was maintained by spraying water on the sand each morning and evening.

In the second method, one clutch from each pond was incubated in circular fiber containers 75 cm in diameter. Eggs were placed on 10 cm of sand and again were covered with 20 cm of additional sand at KIFRDC. The fiber containers were placed in water to protect the eggs from ants and other insects. Water was sprayed on the sand every morning and evening to control the sand moisture content. Water loss was minimized by placing a plastic cover securely over the top of each container.

In the third method, two clutches from each pond were incubated at the nesting area in situ. After 30 days of incubation, the nests were surrounded by mesh to restrain the hatchlings for counting, measuring, and protection from predators.

In each method, the number of hatchlings emerging was recorded and the respective hatching success rates calculated. Incubation times were also recorded in each method. The hatchlings of all treatments were measured (CW and CL) and weighed. Max-Min mercury thermometers were inserted horizontally near the nests to monitor incubation temperature throughout the incubation period. Air temperatures and sand moisture content were also recorded in each method during the studies. Sand moisture content (%) was calculated from [(wet weight – dry weight) / dry weight] x 100.

Growth of hatchlings

Twenty hatchlings, from A1/KIFRDC (Table 7.3), were divided into two groups. They were reared indoors in two glass aquaria, 50x105x40 cm. Sand covered the bottom of the aquaria to a depth of about 4 cm. The hatchlings in each aquarium were provided with 3 cm water. Water was exchanged every Tuesday and Friday. Fry fish of Labeo rohita (Hamilton, 1822), (23.27±1.57 mm length and 0.12±0.05 g weight), Oreochromis niloticus (Linnaeus, 1758), (24.21±1.34 mm length and 0.29+ 0.04 g weight), were fed to C. chitra hatchlings in this study. One hundred fish within the first two months and 200 fish in the third month were provided daily in each aquarium. The total number of fish eaten was recorded daily and was divided by hatchlings in order to estimate the average amount consumed per individual. Weight, carapace width and carapace length of hatchlings were measured every two weeks for fourteen weeks.

Results

Reproduction

Timing of reproductive activity

Reproductive behaviors occurred in both ponds over the nine-month period between August and April in both years of the study. Tracks of the females were observed from August through April, with their frequency increasing in November, and from February through April. Nesting tracks and nests were observed from February through April (Figure 7.3).

In the first year of our study, the first copulation observed involved the 44 kg male and female in Pond A on 6 September 2000, at 6.00 A.M. about four months after his release into the pond. Other copulations occurred between 3 December 2000 and 3 April 2001 mainly between 6.15 A.M. and 8.30 A.M. (Table 7.1 and 7.2), with the males being most active between

December and February. At this time, males often chased the females and attempted to copulate.

In the second year, copulation occurred between December and February (Table 7.2). Copulations lasted between 10-15 minutes in both years of study (Table 7.2).

Table 7.2 Date of copulation and mating duration of C. chitra in pond A.

Nesting year	Copulation times	Mating duration
2001	- 6 September 2000; 6.00 am	~10 min
	- 3 December 2000; 8.00 am	~10 min
	- 22 February 2001; 7.30 am	~10 min
	- 2 April 2001; 8.30 am	~10 min
	- 3 April 2001; 6.15 am	~10 min
2002	- 29 December 2001; 2.00 p.m.	~10 min
	- 27 February 2002; 9.40 am	~15 min

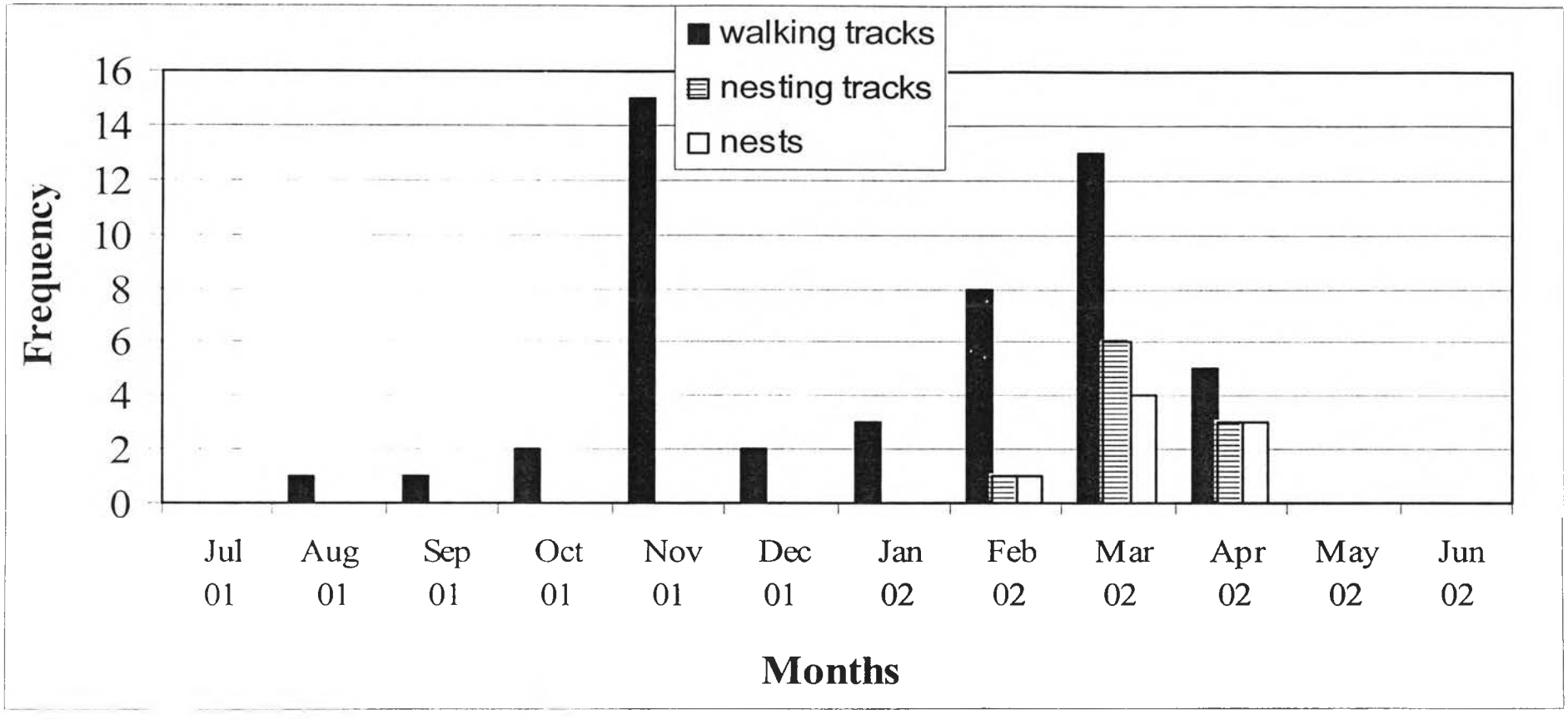

Figure 7.3 Terrestrial activities of C. chitra in pond A; walking tracks, nesting tracks and nests between July 2001 and June 2002.

Nesting

Nesting occurred on the artificial sandbanks. Walking tracks, which may represent exploratory behavior by the females, were found before nesting actually occurred. The first nesting track was found in the morning of 22 February 2001 in Pond A, but the actual nest site was not located. Several additional nest tracks and presumed nests (i.e. large areas of disturbed sand) were found during March to April. On 7 June 2001, after heavy rains and rising water levels within the pond enclosures, Chitra eggs were discovered on the sand surface near the water's edge. Subsequently the sandbank was excavated and four clutches of eggs were removed from flooded nests.

One year later, nesting tracks were found in the morning in both Pond A and Pond B from 27 February to 20 April 2002. Nests were excavated within 48 hours after they were constructed. The nest hole of C. chitra is flask-shaped. The mean of four egg chambers of Pond A was 23.5 cm width, 32.5 cm height from sand surface to top of egg clutch, and 54 cm height from sand surface to nest bottom. The average of four egg chambers of Pond B was 22.8 cm, 32 cm, and 49.3 cm, respectively. The nest dimensions of the smaller female were less than those of the larger female (Table 7.3).

Table 7.3 Hatching success and other parameters for the three incubation methods. Abbreviations: KIFRDC, Kanchanaburi Inland Fisheries Research and Development Center; CU, Chulalongkorn University; ASB, Artificial sandbank;, Size of egg chamber, width (W), height of ground surface to egg top (ET), height of nest bottom to ground surface (NB). Number in parentheses indicates the number of eggs which were found in the original nests.

Pond/Method	Nesting Date	Hatching Date	Egg chamber (W, ET, NB) cm	No. of eggs incubated	Sand Temp. (^{0}C)	Air Temp. (^{0}C)	No. of hatchlings emerged	Incubation time (days)	Hatch rate (%)
A1/KIFRDC	16/3/2002	10-14/5/2002	23, 40, 58	44(45)	24-38	24-42	35	55-59	80
A2/CU	21/3/2002	15-19/5/2002	23, 28, 49	87(88)	26-33.5	25-34	78	55-59	90
A3/ASB	4/4/2002	3/6/2002	22, 30, 54	79(79)	26-35	24-39	74	60	94
A4/ASB	20/4/2002	19-21/6/2002	26, 32, 55	65(68)	26-35	24-39	57	62-64	88
B1/KIFRDC	21/3/2002	18/5/2002	23, 30, 48	40(40)	24-39	24-41	1	58	3
B2/CU	27/2/2002	3/5/2002	25, 35, 50	*22(40)	26-33.5	25-34	1	65	5
B3/ASB	?	16-21/5/2002	22, 30, 50	67(67)	26-35	24-39	44	?	66
B4/ASB	3/4/2002	3-7/6/2002	21, 33, 49	58(58)	26-35	24-39	9	61-65	16

? Actual nesting date not observed.

* Eggs were found at 2 weeks old. The infertile eggs were removed.

Table 7.4 Size of eggs and hatchlings of captive C. chitra. Numbers in brackets of no. of eggs and no. of hatchlings indicate the number of eggs and hatchlings which were measured. Numbers in parentheses indicates standard deviation (SD).

Pond	Year	Clutch	No. of egg	Egg width (mm)	Egg length (mm)	Egg Wet mass (g)	No. of hatchling	Hatchling CW (mm)	Hatchling CL (mm)	Hatchling Wet mass (g)
A	2001	A1	74[-]	-	-	-	-	-	-	-
		A2	64[-]	-	-	-	-	-	-	-
		A3	76[76]	33.08(0.43)	33.48(0.82)	20.41(0.77)	-	-	-	-
		A4	1[-]	-	-	-	1[1]	-	-	13.34
	2002	A1	45[44]	32.67(0.44)	33.05(0.51)	19.72(0.70)	35[35]	38.86(1.60)	43.07(1.11)	13.48(0.65)
		A2	88[35]	32.19(0.53)	32.68(0.50)	19.14(0.72)	78[78]	38.22(1.26)	43.98(0.93)	13.65(0.54)
		A3	79[-]	-	-	-	74[74]	39.32(1.27)	43.12(0.89)	13.65(0.49)
		A4	68[-]	-	-	-	57[57]	38.22(1.56)	42.99(1.56)	12.79(0.70)
Mean of pond A				32.76(0.58)[a]	33.18(0.75)	19.93(0.90)[a]		38.65(1.47)[a]	43.36(1.20)[a]	13.43(0.68)[a]
Range				30.10-34.37	30.99-38.87	15.58-21.60		33.32-41.67	39.20-46.66	11.27-14.89
B	2002	B1	40[25]	28.87(1.47)	35.50(2.59)	16.70(0.66)	1[1]	32.02	38.23	10.76
		B2	40[40]	30.68(0.95)	31.63(1.02)	16.85(0.86)	1[1]	35.70	40.48	11.57
		B3	67[-]	-	-	-	44[42]	37.82(0.99)	41.70(1.68)	11.82(0.88)
		B4	58[-]	-	-	-	9[9]	37.72(2.62)	39.33(1.99)	10.57(0.95)
Mean of pond B				29.98(1.46)[b]	33.12(2.60)	16.79(0.78)[b]		37.61(1.73)[b]	41.20(1.96)[b]	11.59(0.99)[b]
Range				26.89-33.40	29.39-40.49	15.31-18.40		32.00-41.17	36.27-45.41	9.09-13.43
Total mean				31.94(1.57)	33.16(1.54)	19.00(1.67)		38.46(1.52)	42.97(1.59)	13.10(1.03)
Total range				26.89-34.37	29.39-40.49	15.31-21.60		32.00-41.67	36.27-46.66	9.09-14.89

Clutch size

Clutch size ranged from 1 to 88 eggs, although it seems likely that the single egg clutch represents aberrant "nesting". The total eggs from the Pond A female were 215 eggs, from clutches of 74, 64, 76, and 1 egg in 2001. In 2002, the female of Pond A laid 280 eggs from clutches of 45, 88, 79, and 68, respectively. Also in 2002, the female of Pond B laid 205 eggs with clutches of 40, 40, 67, and 58 eggs, respectively (Tables 7.3 and 7.4). Both females deposited four clutches each in nesting season of 35 days at intervals of 5-23 days (Table 7.3).

Egg size

Most C. chitra eggs were white and spherically shaped, but a few were more oblong. The smaller female produced more elongate eggs. Eggshells were brittle and easily broken. The mean dimensions of the eggs (n = 220) were 31.94±1.57 mm width (range 26.89-34.37 mm) and 33.16±1.54 mm length (range 29.39-40.49 mm). Mean egg weight was 19.00±1.67 g (range 15.31-21.60 g) (Table 7.4). Comparison of egg size between the two females revealed that egg width and weight were significantly different between the two females although egg length was not (Table 7.4). The larger female laid wider and heavier eggs than the smaller female.

Incubation and Hatching Success

Mean incubation time of C. chitra eggs was 59±3 days (n = 255) with a range of 55-65 days (Table 7.3) at 24-42 ^{o}C air temperature and 24-39 ^{o}C sand temperatures (Figure 7.4).

Within a clutch, hatching varied from 1-5 days between first and last egg pipping. Only in the A3/ASB clutch that was incubated in the nest area did all hatchlings (n = 74) emerge at the same time (60 days). In the other clutches the eggs hatched over a 3-5 day period. For the 2002 year,

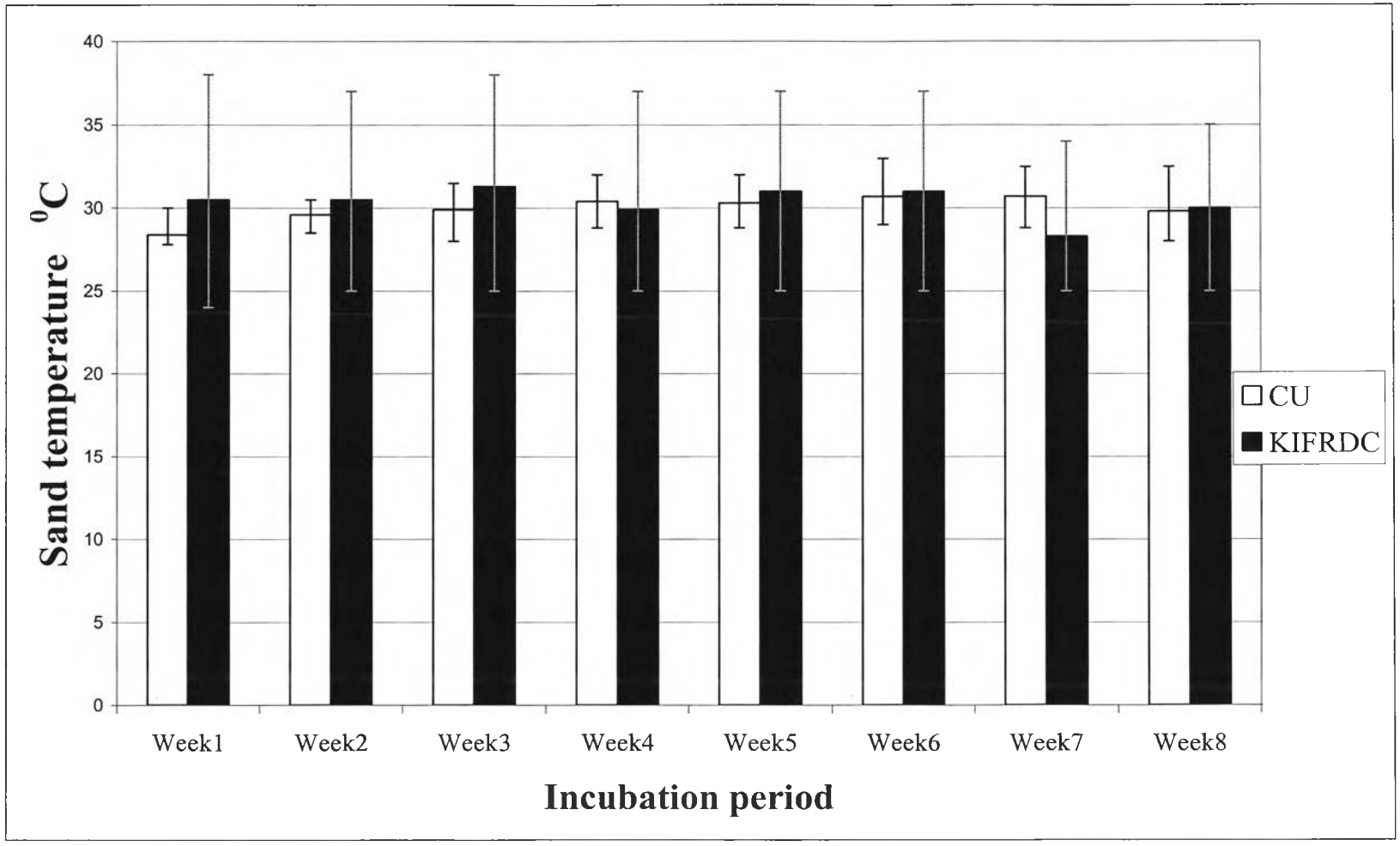

Figure 7.4 Sand temperature during C. chitra's eggs incubation in KIFRDC and CU methods. The vertical solid bars show maximum and minimum of sand temperatures. Sand temperature of ASB was recorded as only max-min throughout the study.

the hatching success rates of the larger female's clutches incubated with the three methods ranged from 80 to 94 % (Table 7.3). Hatching success of the smaller female's clutches was much less, 3 to 66 % (Table 7.3). The hatch rates of the Pond A female were not significantly different among incubation methods. The hatch rate of Pond B was highest in B3/ASB1 clutch (66%) while hatch rates of the other clutches were very low. Air temperature ranged widely in all incubation methods; 24-42, 25-34 and 24-39 $^{\circ}$C of KIFRDC, CU and ASB, respectively (Table 7.3). While sand temperatures in the CU method varied less than in the KIFRDC and ASB methods 24-39, 26-33.5 and 26-35 $^{\circ}$C of KIFRDC, CU and ASB, respectively (Table 7.3). However, sand temperature in the ASB method was recorded as only max-min throughout the study (Figure 7.4).

Moisture contents of sand in CU, KIFRDC and ASB were 4.64±0.53 (range = 4-5.8), 5.16±0.36 (range = 4.8-6) and 3.78±0.19 (range = 3.6-4.2) %, respectively. The moisture content of ASB is lower than in the CU and KIFRDC methods (Figure 7.5).

Hatchling size

The mean hatchling sizes were 38.46±1.52 mm carapace width (range 32.00-41.67 mm), 42.97±1.59 mm carapace length (range 36.27-46.66 mm) and 13.10±1.03 g weight (range 9.09-14.89 g). Hatchling sizes from Pond A and Pond B were compared by t-test analysis. Hatchlings from Pond A were significantly wider, longer, and heavier than Pond B hatchlings (Table 7.4).

Growth

The mean sizes of 21 day-old hatchlings were 41.35±0.57 cm carapace width, 44.53±0.62 carapace length and 13.99±0.60 g weight. After 14 weeks, mean hatchling size was 86.70±5.17 mm carapace width, 91.72±5.75 mm

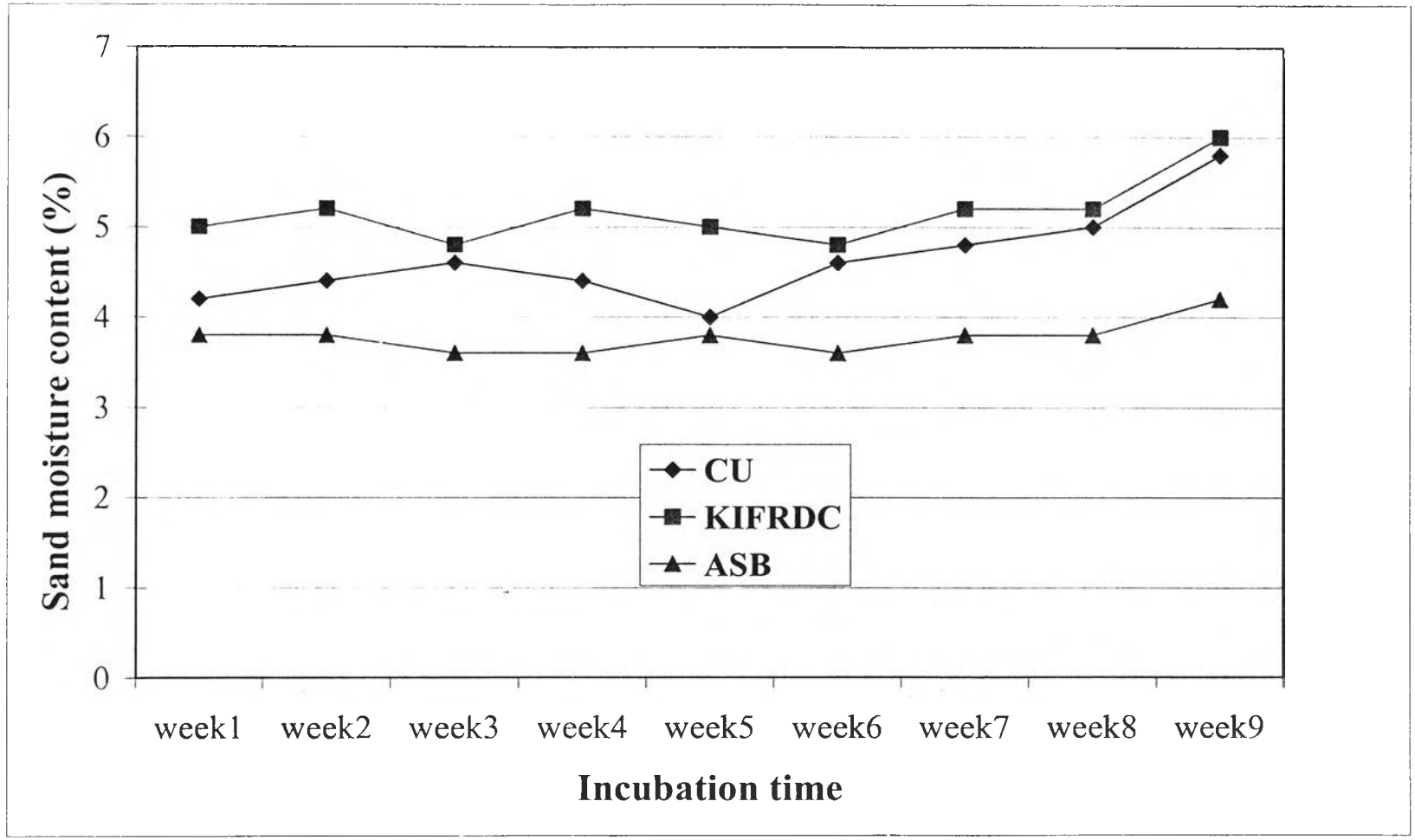

Figure 7.5 Moisture content of sand during incubation in CU, KIFRDC and ASB methods for egg treatments from pond A.

carapace length and 103.97±18.08 g weight, respectively. Moreover, the survival rate of these hatchlings was 90.64% for the test interval.

Figure 7.6 shows the relationships between CW, CL, Wt and age for 19 hatchlings (1 of them died after 2 weeks). It shows that CL and CW are strongly correlated with one another as well as with age, and that weight increase is strongly correlated with age (Figure 7.6). Another significant relationship was established between weight of food consumed per day and hatchling weight over a 14-week observation period (Figure 7.7).

Discussion

Mating and Nesting

The peak mating time of C. chitra observed in captivity, from December to February (Figure 7.2), is similar to the January to February mating season observed in nature (Taechacharernsukchera, 1991). Walking tracks (Figure 7.3) were found from August to April, with two peaks in November and March. The first terrestrial activity occurs before mating time and may be an exploration for suitable nesting sites. The second activity was for nesting, and nesting tracks and nests (Figure 7.3) were found from February to April. Some nests were constructed, but eggs were not deposited. These empty nests presumably result from disturbance of the nesting female and her abandonment of the nesting behavior. Similar occurrences of empty Chitra nests have been observed in nature. Fishermen and local people believe that Chitra constructs false nests to distract the egg predator *Varanus salvator* from locating the true nest. All captive C. chitra nested nocturnally, perhaps to avoid the high daytime temperatures (34-42° C) during the nesting season (Figure 7.2). The captives nested in late winter to late summer (February to May) when warmer temperatures provide appropriate thermal conditions for egg incubation. The captives' nesting season is probably similar to that in

nature. However, we found one clutch of wild C. chitra in Vajiralongkorn Reservoir (formerly Khoa Lam Reservoir) on 14 January 2000.

Knowledge of egg and clutch parameter is relatively well known in sea turtles, but these data are still lacking for many other turtle species (Moll, 1979; Gibbons and Greene, 1990). In this study, two C. chitra produced four clutches each in one breeding season after the larger female produced three or four (depending on whether the one egg clutch is counted) clutches the preceding year. Taechacharernsukchera (1991) dissected a dead female C. chitra that contained 97 hard-shelled oviducal eggs and 270 follicles. The size differences between follicles observed (3-4 groups) suggest that four to five clutches are laid by females each nesting season. The factors influencing the number of clutches per year are unknown. Clutch frequency of C. chitra in this study (based upon two years from Pond A and one year from Pond B) provides the first direct evidence that Chitra can lay multiple clutches (up to four) within a nesting season.

Multiple clutches hatching at intervals would provide some Chitra hatchlings an opportunity to avoid egg and hatchling predators and/or unfavorable weather conditions during portions of the hatching season.

Clutch size of C. chitra ranged from 40 to 88 eggs in this study, whereas Taechacharernsukchera (1991) found 97 eggs in a wild clutch, Nutphand (1990) stated that C. chitra normally laid 60 to 110 eggs per clutch. The highest number of eggs per clutch in C. chitra was recorded as 117 eggs (Nutphand, 1986). These data support the view that C. chitra should be classified as possessing reproductive Pattern I as defined by Moll, 1979. This pattern is characterized by the production of large clutches; multiple clutches produced during a well-defined nesting season; communal nesting in a well-defined ancestral nesting area; and careful construction of covered nests.

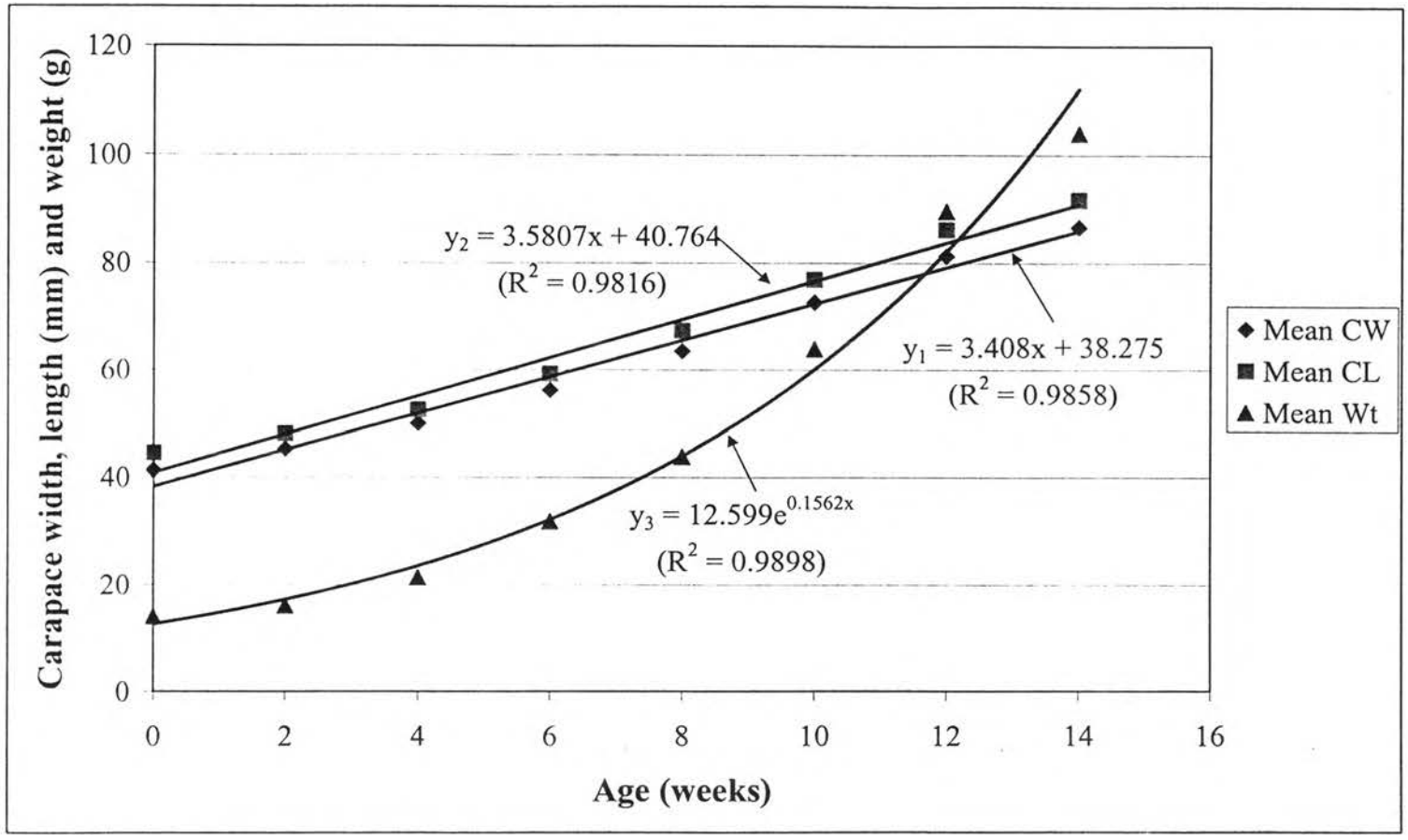

Figure 7.6 Carapace width, carapace length and weight of C. chitra hatchlings for 14 weeks.

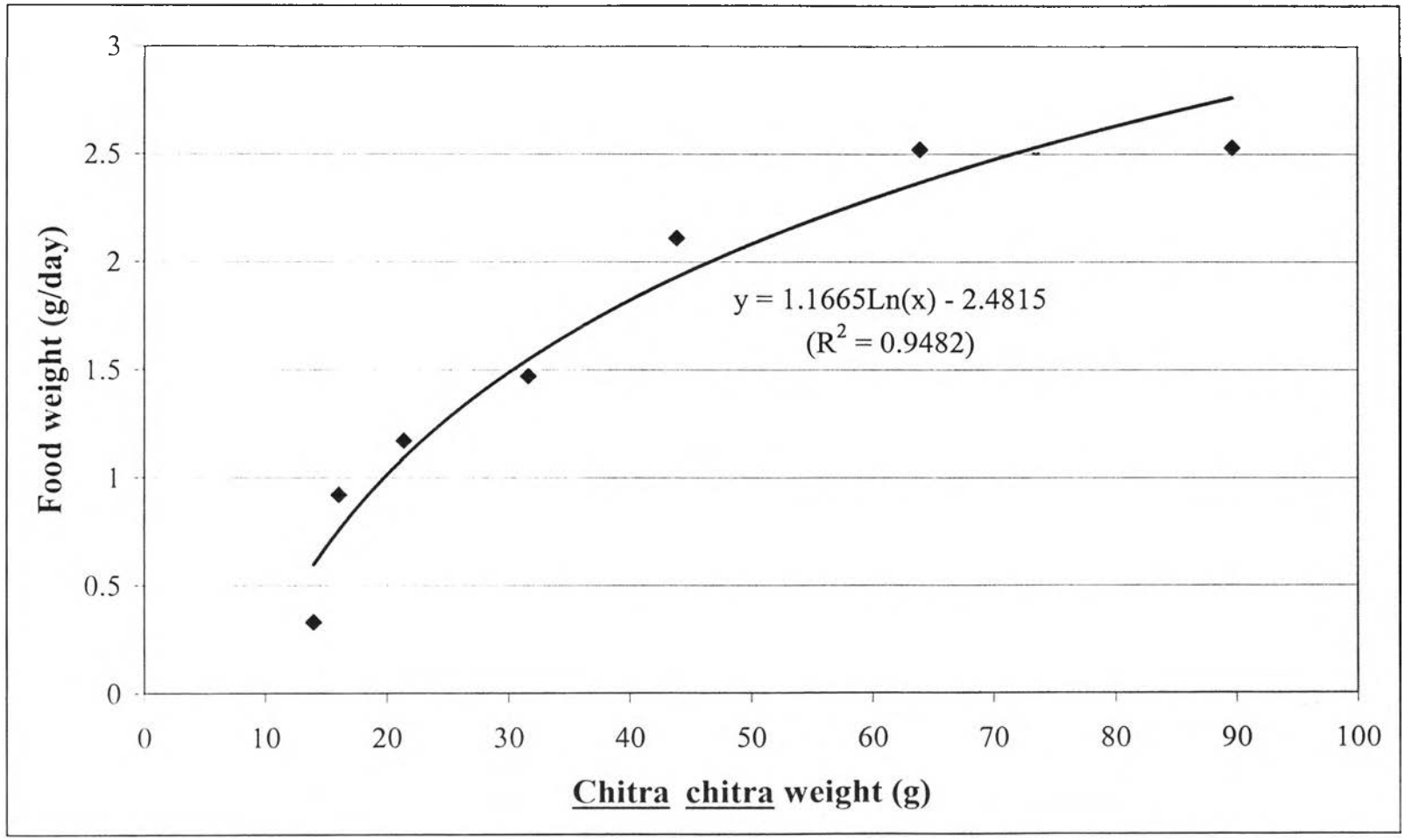

Figure 7.7 Relationship between weight (g) of C. chitra hatchling and food weight (g) per day.

Sea turtles and many other larger riverine turtles also display Pattern I reproductive strategies.

The limited data available suggest that larger Chitra lay larger egg clutches than smaller individuals. This trend has been observed in other turtle species (Moll, 1979; Gibbons, 1982) although environmental influences may also influence clutch sizes to some extent.

Egg size and shape

Chitra chitra laid spherical eggs with white, brittle eggshells morphologically similar to those produced by other softshell turtles (see previous section on egg morphology).

Egg size of C. chitra is small compared to maternal body size. The large C. chitra female laid larger eggs than the smaller female, a trend similar to that seen in sea turtles and other freshwater turtle species (van Buskirk and Crowder, 1994; Miller, 1997; Kuchling, 1999). The smaller female produced more elongated eggs. Perhaps this might reflect the physical constraints by the diameter of the oviducts or a pelvic girdle constraint (Congdon and Gibbons, 1987) of newly matured females.

Incubation time

The incubation times of turtle eggs depend mainly on temperature and humidity. Previous studies showed that incubation times of Testudo hermanni boettgeri eggs incubated at high constant temperatures are shorter than those incubated at low constant temperature (Eendebak, 1995). At the same incubation temperatures, Chrysemys picta eggs in wetter substrates required more time to hatch than those from drier substrates (Packard et al., 1991). Temperatures and soil moisture levels in incubation methods employed in this study were not controlled. The eggs were incubated in fluctuating

temperatures (24-39 ^{o} C sand temperature), and relatively moist substrates so that the effects of these and perhaps other environmental influences on incubation time cannot be determined from this study. However, the moisture content in the last week of each method is higher due to water infused from hatching eggs (Figure 7.5).

Hatching Success

The successful hatching of turtle eggs depends upon temperature, humidity, and air circulation. The hatch rate of C. chitra eggs in this study in Pond A did not differ among the three methods used (Table 7.3). The hatch rates were all high, > 80%, therefore, we conclude that conditions in all incubating methods were appropriate for incubation of C. chitra eggs. Although the hatching success of eggs from Pond B was lower than that from Pond A (3-66 vs. 80-94%), both sets of eggs were incubated under similar conditions. Perhaps the smaller (71 kg) female was ovipositing for the first time (anecdotal evidence suggests that C. chitra females mature at 60 kg or more) and she was physiologically deficient for effective reproductive success.

Hatchling size

Hatchling sizes of C. chitra are very small and similar to sizes recorded for *C. indica* hatchlings (43 and 38 mm CL and CW and 10 g Wt and 39 and 33 mm of CL and CW and 7 g Wt) (Sachsse, 1971). Larger C. chitra eggs produced larger hatchlings (Table 7.4), a trait also known in sea turtles and other freshwater turtle species (van Buskirk and Crowder, 1994; Kuchling, 1999).

Growth

Growth of C. chitra including (CW, CL and Wt) is very rapid during the first 14 weeks. The result was compared with growth of C. indica hatchlings that were studied by Sachsse (1971). The initial sizes of C. indica were 43

and 38 mm of CL and CW and 10 g Wt and 39 and 33 mm of CL and CW and 7 g Wt. After 2 months, their measurements were 44 and 38 mm of CL and CW and 11 g Wt and 40 and 33 mm of CL and CW and 10 g Wt, respectively. In this study the growth rate of C. chitra was much higher in the first 2-3 months than observed in C. indica. Hatchlings from captive breeding have a better chance than animals from the wild. However, growth of C. chitra is probably not maintained at this rate. Two hatchlings of wild caught C. chitra were maintained at Kanchanaburi Inland Fisheries Research and Development Center for nine years. Their sizes are 59 and 63 cm CW, 68 and 71 cm CL and 29 and 36 kg Wt, respectively (Kitimasak, unpublished data) on August 2002.

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