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Captive bred hybrids between *Chinemys reevesii* (GRAY, 1831) and *Cuora amboinensis kamaroma* RUMMLER & FRITZ, 1991

(Testudines: Geoemydidae [1])

Gefangenschaftshybriden zwischen *Chinemys reevesii* (GRAY, 1831) und *Cuora amboinensis kamaroma* RUMMLER & FRITZ, 1991

(Testudines: Geoemydidae [1])

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KURZFASSUNG

Von 1999 bis 2001 schlüpften in der Obhut des Erstautors insgesamt 14 Hybriden zwischen einer männlichen *Chinemys reevesii* (GRAY, 1831) und einer weiblichen *Cuora amboinensis kamaroma* RUMMLER & FRITZ, 1991. Ein weiteres, mißgebildetes Exemplar starb kurz vor dem Schlupf ab. Der Schlupferfolg betrug 58 % (14 von 24 Eiern, alle Eier befruchtet). Die Haltung der Elterntiere und der nachgezüchteten Hybriden wird geschildert. Höchstwahrscheinlich war das *Ch. reevesii* - Männchen durch die gemeinsame Aufzucht mit *C. a. kamaroma* auf dieses Taxon geprägt worden. Die Hybriden werden beschrieben. Phänotypisch sind sie zwischen beiden Elternarten intermediär. Dreizehn Exemplare erinnern eher an *C. a. kamaroma*, weisen jedoch drei sehr deutliche Carapaxkiele auf. Ein Hybride ähnelt *Ch. reevesii* stärker als seine Geschwister. Das Plastron trägt entweder ein Fleckenmuster, ähnlich wie bei *C. a. kamaroma* (7 Exemplare, inklusive des mißgebildeten Embryos), oder ist nahezu einfarbig dunkel, ähnlich wie bei *Ch. reevesii* (8 Exemplare). Ein Hybride ging nach 25 Monaten ein. Die anderen 13 Exemplare gedeihen sehr gut. Zu ihrem Wachstum werden einige Angaben gemacht. Dies ist der erste detaillierte Bericht über in Gefangenschaft gezüchtete Gattungshybriden bei südostasiatischen geoemydiden Schildkröten.

ABSTRACT

Under the custody of the first author, a total of 14 hybrids between a male *Chinemys reevesii* (GRAY, 1831) and a female *Cuora amboinensis kamaroma* RUMMLER & FRITZ, 1991 hatched from 1999 to 2001. A further specimen was malformed and died prior to hatching. Hatching success was 58 % (14 out of 24 eggs, all eggs fertilized). The maintenance of the parental specimens and of the hybrid young is described. Most likely, the male *Ch. reevesii* was imprinted to *C. a. kamaroma* as it was raised with *C. a. kamaroma* specimens. A description of the hybrids is given. Phenotypically, they are intermediate between both parental species. Thirteen specimens appear to most closely resemble *C. a. kamaroma* but have three very distinct carapacial keels. One hybrid resembles *Ch. reevesii* more than its siblings. The plastron is either blotched, as in *C. a. kamaroma* (7 specimens, including the malformed embryo), or almost entirely dark as in *Ch. reevesii* (8 specimens). One hybrid died after 25 months. The other 13 specimens are doing very well. Some data on their growth are presented. This is the first detailed report of captive bred intergeneric hybrids in South-east Asian geoemydid turtles.

KEY WORDS

Reptilia: Testudines: Geoemydidae; *Chinemys reevesii*; *Cuora amboinensis kamaroma*; intergeneric hybrids in captivity, malformation, development

INTRODUCTION

FRITZ & BAUR (1995) and FRITZ (1995) recently reviewed the known cases of chelonian hybrids. They reported a fair number of hybrids between congeneric taxa (species and subspecies), but comparatively fewer intergeneric hybrids: Chelidae: *Chelodina longicollis* (SHAW, 1802) x *Emydura subglobosa* (KREFFT, 1876), *Elseya novaeguineae* (MEYER, 1874) x *Emydura subglobosa* (KREFFT, 1876); Cheloniidae: *Caretta*

1) Geoemydidae is used as BOUR & DUBOIS (1986) demonstrated that this name has nomenclatural priority over Bataguridae.

caretta (LINNAEUS, 1758) x *Eretmochelys imbricata* (LINNAEUS, 1766), *Chelonia mydas* (LINNAEUS, 1758) x *Eretmochelys imbricata* (LINNAEUS, 1766); Testudinidae: *Astrochelys radiata* (SHAW, 1802) x *Chelonoidis carbonaria* (SPIX, 1824), *Agrionemys horsfieldii* (GRAY, 1844) x *Testudo hermanni* GMELIN, 1789. Other authors reported intergeneric hybrids between the following taxa: Emydidae: *Actinemys marmorata* (BAIRD & GIRARD, 1852) x *Emys orbicularis* (LINNAEUS, 1758) (FRITZ 2001), *Clemmys guttata* (SCHNEIDER, 1792) x *Glyptemys muhlenbergii* (SCHOEPFF, 1801) (ERNST 1983), *Emydoidea blandingii* (HOLBROOK, 1838) x *Glyptemys insculpta* (LE CONTE, 1830 [1829]) (HARDING & DAVIS 1999); Geoemydidae: *Chinemys reevesii* (GRAY, 1831) x *Mauremys japonica* (TEMMINCK & SCHLEGEL, 1833) (YASUKAWA et al. 1992), *Cuora amboinensis kamaroma* RUMMLER & FRITZ, 1991 x *Mauremys annamensis* (SIEBENROCK, 1903) (FRITZ & MENDAU 2002); Trionychidae: *Apalone mutica* (LE SUEUR, 1827) x *Pelodiscus sinensis* (WIEGMANN, 1835 [1834]) (KUZMIN 2002). An anecdotal newspaper report noted natural hybrids between *Geoemyda japonica* FAN, 1931 and *Cuora flavomarginata* (GRAY, 1863) in Japan (ANONYMUS 1995; J. BUSKIRK pers. comm.).

Some of these cases refer to weakly differentiated genera (*Emydura* and *Elseya*, *Astrochelys* and *Chelonoidis*, *Agrionemys* and *Testudo*). Their generic distinctness has been repeatedly questioned in the literature, e. g., by MCDOWELL (1983: *Emydura* and *Elseya*), CRUMLY (1982: *Astrochelys*, *Chelonoidis* and *Geochelone*), ERNST & BARBOUR (1989: *Agrionemys* and *Testudo*; *Astrochelys*, *Chelonoidis* and *Geochelone*), and FRITZ & CHEYLAN (2001: *Agrionemys* and *Testudo*). Others, like *Chelodina* and *Emydura* or *Emydoidea* and *Glyptemys*, are without doubt only distantly related and represent well differentiated genera.

FRITZ & BAUR (1995) and FRITZ (1995) suggested that intergeneric hybrids are rare among chelonians. However, the new examples mentioned above may force us to revise this opinion. Moreover, recent studies prove that some of the newly described geoemydid species from South-east Asia are actually intergeneric hybrids. Molecular data show that *Mauremys iversoni* PRITCHARD & MCCORD, 1991 resulted from hybridization of *Cuora trifasciata* (BELL, 1825) and *M. mutica* (CANTOR, 1842) (PARHAM et al. 2001; WINK et al. 2001), and *Mauremys pritchardi* MCCORD, 1997 from hybridization of *Chinemys reevesii* (GRAY, 1831) and *M. mutica* (CANTOR, 1842) (WINK et al. 2001). *Cuora serrata* IVERSON & MCCORD, 1992 is a hybrid between *Cuora galbinifrons* BOURRET, 1939 and *Pyxidea mouhotii* (GRAY, 1862) (PARHAM et al. 2001). It remains unclear whether "*M. iversoni*", "*M. pritchardi*" and "*C. serrata*" originate from Chinese turtle farms or whether they represent natural hybrids or even "hybridogenic species" (PARHAM et al. 2001; WINK et al. 2001). A hybrid origin is also discussed for other "new species" from South-east Asia (FRITZ & OBST 1999; VAN DIJK 2000; PARHAM et al. 2001).

Reports of well documented cases of captive bred chelonian intergeneric hybrids can shed additional light on this confusing situation. Here we describe the repeated successful hybridization of a male *Chinemys reevesii* and a female *Cuora amboinensis kamaroma* which occurred from 1999 onwards in the collection of the senior author (F. G.). This is the first detailed account of captive bred intergeneric hybrids in South-east Asian geoemydid turtles.

HYBRIDS BETWEEN *CHINEMYS REEVESII* AND *CUORA AMBOINENSIS KAMAROMA*

Parental specimens

In August 1996, the senior author purchased an entirely black adult male *Chinemys reevesii* (GRAY, 1831) and an adult female *Cuora amboinensis kamaroma* RUMMLER & FRITZ, 1991. Both specimens were long-term captives. According to its previous owner, the *Ch. reevesii* male was 12 years old in August 1996. In the past it shared a terrarium with a male *C. a. kamaroma*, as it was aggressive against conspecifics. This aggressive behavior against other *Ch. reevesii* was also observed by the senior

Table 1: Selected data on clutches and eggs of the *Cuora amboinensis kamaroma* female.
Tab. 1: Ausgewählte Daten über Gelege und Eier des *Cuora amboinensis kamaroma* - Weibchens.

Date of egg deposition Eiablagedatum	Clutch size Gelegegröße	Egg length [mm] Eilänge	Egg width [mm] Eidurchmesser	Egg mass [g] Eimasse	Maximum incubation temperature [°C] max. Inkubationstemperatur	Hatchlings Schlüpflinge
01 Oct 1996	1	33	21	7	28	0
20 Mar 1997	3	37 - 39	23 - 24	10 - 12	28	0
26 Apr 1997	3	40 - 42	23	10 - 12	28	0
19 June 1997	2	39, 43	23, 24	10, 13	28	0
11 July 1997	1	41	22	11	28	0
05 Aug 1997	1	41	22	11	28	0
29 Aug 1997	1	41	23	12	28	0
12 Feb 1998	1	39	23	11	28	0
13 Apr 1998	2	42, 44	23, 23	12, 13	28	0
01 June 1998	1	40	23	12	28	0
21 Nov 1998	2	43, 50	24, 25	13, 17	28	0
08 Jan 1999	2	43, 46	24, 25	19, 20	28	2
03 Feb 1999	2	42, 42	23, 24	16, 17	28	0
04 Mar 1999	1	43	23	16	28	0
09 Mar 1999	1	43	24	19	28	1
06 Apr 1999	1	45	23	17	28	0
05 Jan 2000	1	47	26	20	28	1
20 Mar 2000	2	43, 43	23, 23	17, 17	28	2
20 Apr 2000	3	43 - 47	24 - 25	19 - 20	28	2
12 May 2000	2	45, 49	25, 25	19, 21	30	2
09 June 2000	2	44, 48	25, 25	19, 21	30	2
15 July 2000	2	44, 46	23, 24	17, 17	30	1
10 Jan 2001	1	52	26	24	32	0
12 Apr 2001	2	43, 44	25, 25	18, 19	32	0
10 May 2001	2	42, 48	24, 25	14, 18	32	1

author. Therefore it was isolated from other *Ch. reevesii*. When obtained, the body mass of the male *Ch. reevesii* was 165 g and its straight-line carapacial length (SCL) was 10.2 cm. In November 2001, it weighed 256 g and measured 11.2 cm. The female *C. a. kamaroma* had a mass of exactly 900 g and a SCL of 17.0 cm in August 1996. It weighed 1490 g and its SCL was 19.4 cm in November 2001.

Care in captivity

The male *Ch. reevesii* and the female *C. amboinensis kamaroma* are kept indoors in a tank, 100 cm long, 50 cm wide and 90 cm high. Water depth is around 40 cm. A 40 x 50 cm sand-filled container for basking and egg-laying is provided. The tank is heated by a 60 W spotlight and further illuminated by two fluorescent tubes (18 W). Water temperature ranges from 24°C to 28°C; a heating lamp on one side of the tank is used to create a heat gradient. The turtles are fed 2 to 3 times per week with fresh fish, ground meat, dried shrimps, and a commercial pelleted food for aquatic turtles as produced by different companies.

Breeding

It was impossible to keep the male *Ch. reevesii* together with conspecifics as it severely attacked other specimens. It exhibited no aggressive behavior towards the female *C. amboinensis kamaroma*, so both specimens were able to share the same tank. It may be speculated that this male *Ch. reevesii* was imprinted to the other species by chance, as its previous owner had kept it together with *C. a. kamaroma* specimens.

A male *C. a. kamaroma* was obtained as a breeding loan in August 1996, April 1997, and January 1998, and introduced into the tank for a few days each time. In 1997 and 1998 successful copulations were observed. In autumn 1998 the *C. a. kamaroma* female and the *Ch. reevesii* male were observed copulating for four minutes. Otherwise, the *C. a. kamaroma* female was not in contact with any other male turtles during this time period.

Table 2: Dates of egg deposition and hatching, as well as incubation temperatures and periods, shell size and body mass of hatchling hybrids between *Chinemys reevesii* and *Cuora amboinensis kamaroma*. All length measurements are straight line measurements.

Tab. 2: Eiablage- und Schlupfdaten sowie Inkubationstemperatur und -dauer, Panzergröße und Körpermasse bei den frischgeschlüpften Hybriden zwischen *Chinemys reevesii* und *Cuora amboinensis kamaroma*. Alle Längenangaben sind Stockmaße.

Nr	Date of egg deposition Eiablage-datum	Date of hatching Schlupf-datum	Max. incubation temperature [°C] Maximale Inkubationstemperatur	Incubation period [days] Inkubations-dauer [Tage]	Carapace length [mm] Carapax-länge	Carapace width [mm] Carapax-breite	Shell height [mm] Panzerhöhe	Body mass [g] Körper-masse
1	08 Jan 1999	22 Mar 1999	28	73	35	28	18	8
2	08 Jan 1999	23 Mar 1999	28	74	33	26	16	8
3	09 Mar 1999	28 May 1999	28	79	35	28	16	8
4	05 Jan 2000	30 Mar 2000	28	85	31	27	18	9
5	20 Mar 2000	03 Jun 2000	28	75	36	28	17	8
6	20 Mar 2000	03 Jun 2000	28	75	35	28	16	8
7	20 Apr 2000	02 Jul 2000	28	73	38	28	17	10
8	20 Apr 2000	02 Jul 2000	28	73	37	30	18	9
9	12 May 2000	19 Jul 2000	30	68	39	28	19	12
10	12 May 2000	20 Jul 2000	30	69	37	28	17	10
11	09 Jun 2000	18 Aug 2000	30	70	36	27	16	9
12	09 Jun 2000	19 Aug 2000	30	71	37	27	17	10
13	15 Jul 2000	19 Sep 2000	30	70	36	26	17	9
14	10 May 2001	06 Jul 2001	32	57	37	29	16	9

Egg deposition, incubation and hatching success

The female *C. amboinensis kamaroma* produced its first clutch in October 1996. Later, it laid additional clutches of 1 to 3 eggs. The female buried the eggs 3 to 10 cm deep in the sand-filled container. Over the years, more clutches were produced from January to June than in the second halfs of the years. However, with the exception of September and December, nesting was recorded in all months (table 1). Before nesting, the female exhibited a characteristic, nervous behavior for up to one week. Sometimes it started to dig nest cavities days before egg laying occurred.

All eggs were incubated in Vermiculite® substrate (Schundler Co., Metuchen, New Jersey, USA) in an incubator as described by BUDDE (1980). During the night, incubation temperatures were lowered by 5°C. The relative humidity in the incubator was 80-90 %. Maximum incubation temperatures, data on clutch and egg size, egg mass, and hatching success are summarized in table 1.

Not a single egg from the seasons of 1996-1998 developed, despite the observed copulations with the added *C. a. kamaroma* male which has otherwise proven to be a successful breeder.

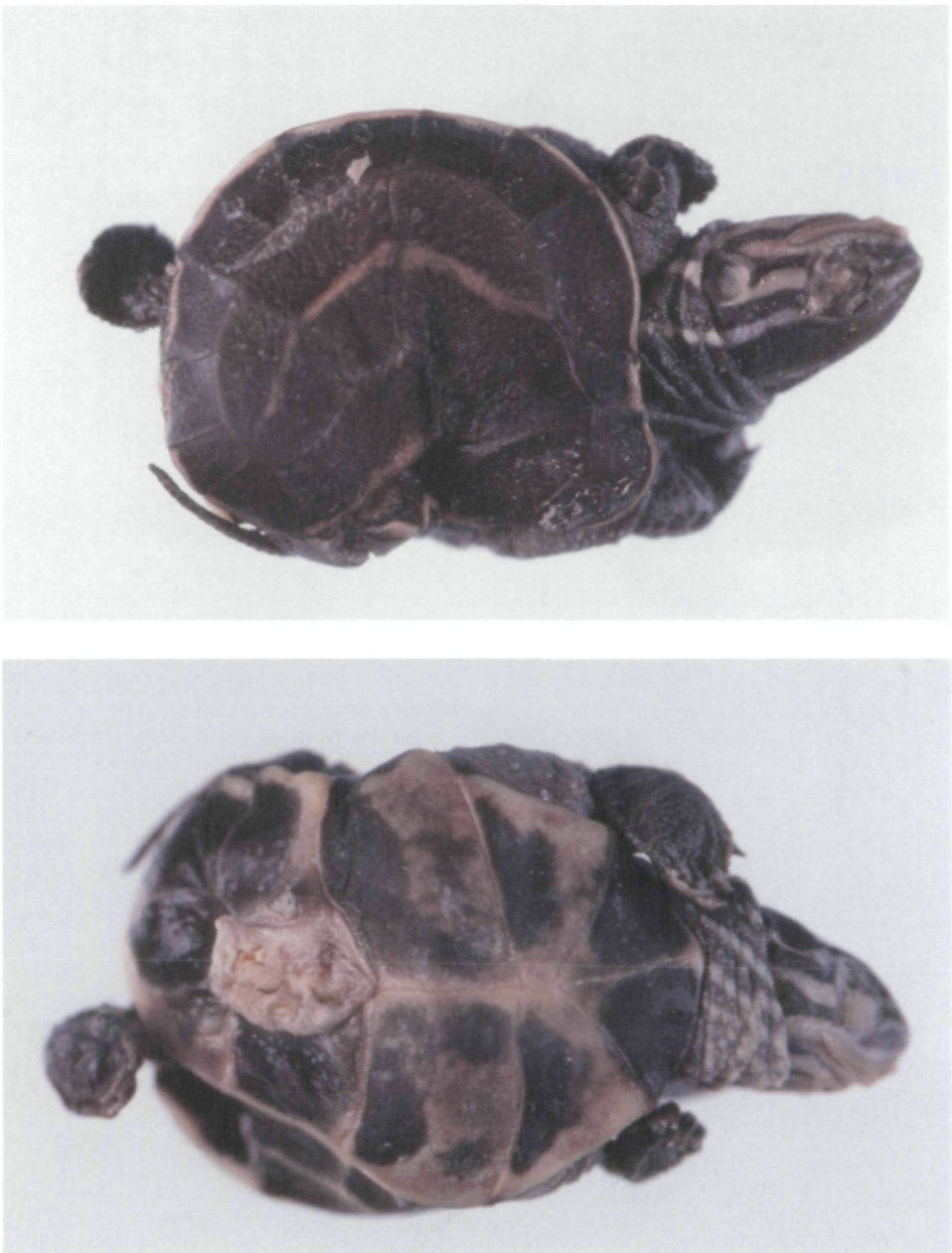
From 1999 onwards, all eggs were fertile and developed the characteristic whitening in the form of a ring, indicating the adhesion of the vitelline membrane of the developing embryo (EWERT 1979). However, not all eggs completed development. Until now, 14 specimens hatched (i. e., 58 % of 24 eggs; table 1) and a further malformed specimen died prior to hatching.

The young hatched after 57 to 85 days at maximum incubation temperatures of 28°C to 32°C (table 2). The poor hatching success of the year 2001 occurred when the highest maximum incubation temperature of 32°C was used.

Hybrid specimens

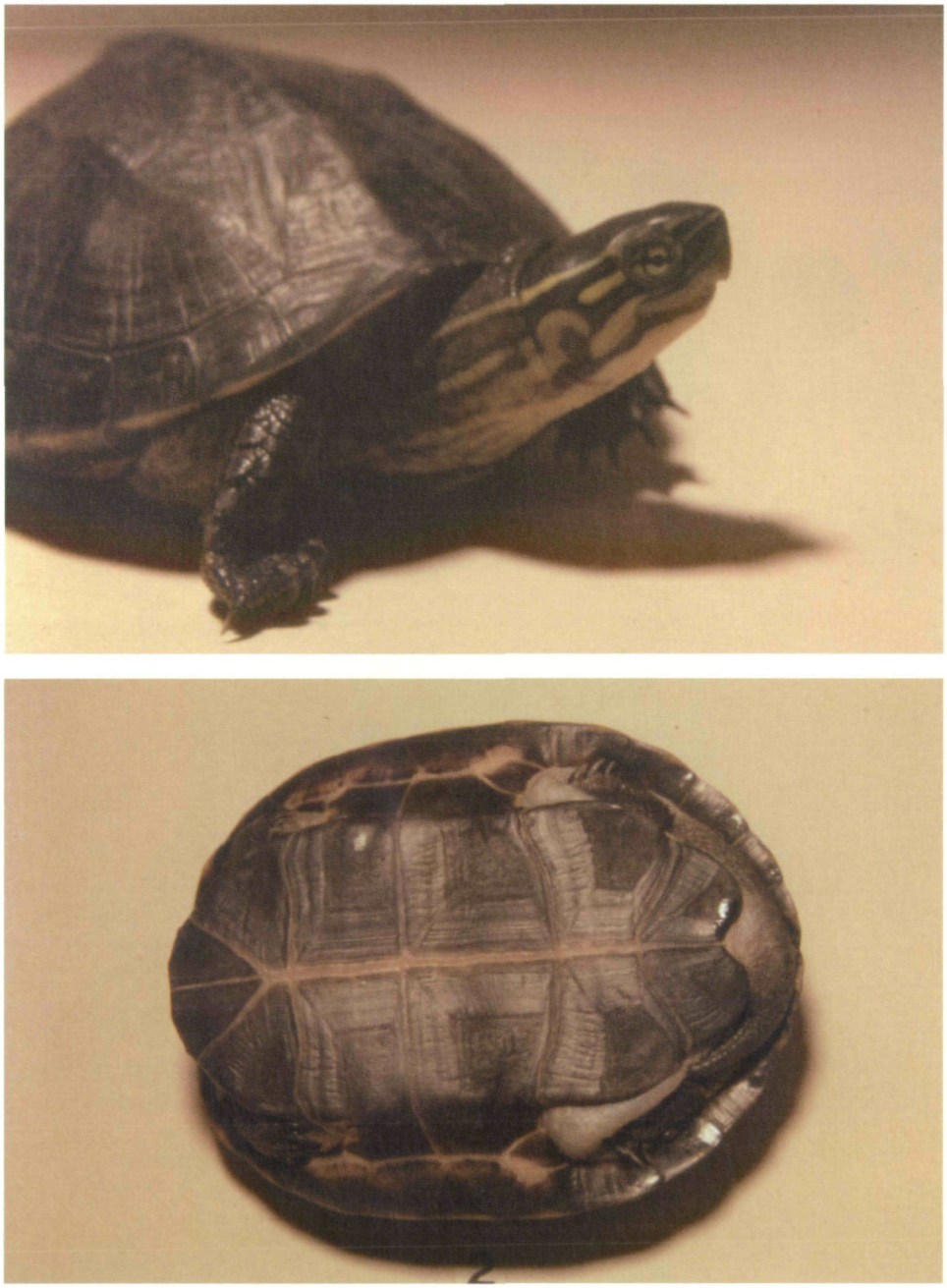
All hatchlings displayed intermediate morphological characters between *Chinemys reevesii* and *Cuora amboinensis kamaroma* and most probably were hybrids between the *Ch. reevesii* male and the *C. a. kamaroma* female.

All turtles were very vigorous and started to feed soon after hatching. However, one specimen (hatched on 28 May 1999; specimen 3 in tables 2-4) unexpected-



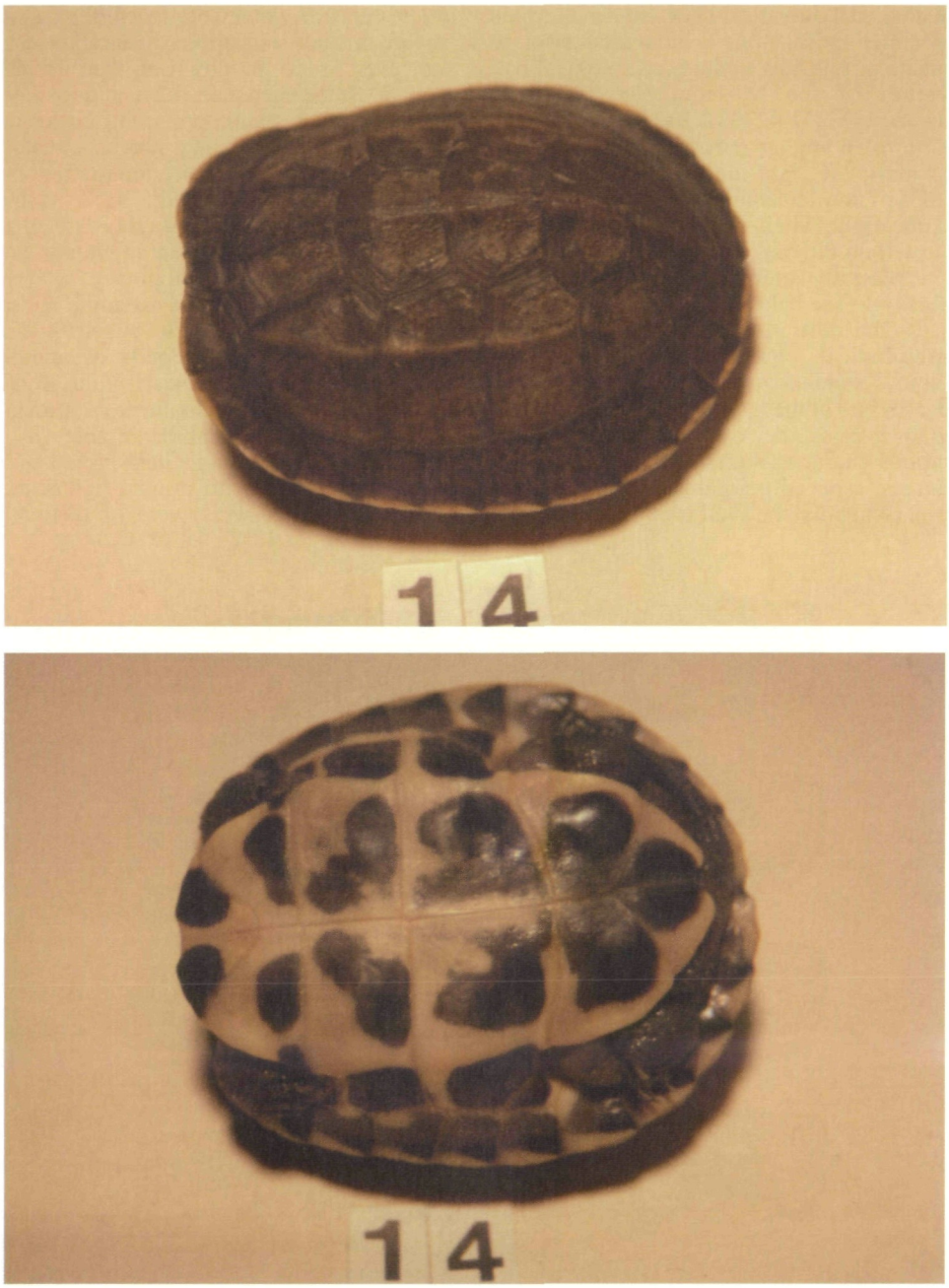
Figs. 1 - 2: Dorsal (top) and ventral aspect (bottom) of a malformed hybrid *Chinemys reevesii* x *Cuora amboinensis kamaroma* (MTD 42993).

Abb. 1 - 2: Dorsal- (oben) und Ventralansicht (unten) des mißgebildeten Hybriden *Chinemys reevesii* x *Cuora amboinensis kamaroma* (MTD 42993).



Figs. 3 - 4: Lateral (top) and ventral aspect (bottom) of a hybrid *Chinemys reevesii* x *Cuora amboinensis kamaroma* with dark plastron (specimen number 2).

Abb. 3 - 4: Lateral- (oben) und Ventralansicht (unten) eines Hybriden *Chinemys reevesii* x *Cuora amboinensis kamaroma* mit dunklem Plastron (Exemplar Nummer 2).



Figs. 5 - 6: Dorsal (top) and ventral aspect (bottom) of a hybrid *Chinemys reevesii* x *Cuora amboinensis kamaroma* with blotched plastron (specimen number 14). Note the distinct carapacial keels.

Abb. 5 - 6: Dorsal- (oben) und Ventralansicht (unten) eines Hybriden *Chinemys reevesii* x *Cuora amboinensis kamaroma* mit gefleckter Plastron (Exemplar Nummer 14). Man beachte die deutlichen Rückenkiele.

ly died on 1 July 2001. The only malformed specimen is that one which died prior to hatching. It is now in the herpetological collection of the Museum für Tierkunde Dresden (MTD 42993). Its shell is entirely malformed and asymmetrical (SCL approx. 24 mm); the right hindleg is vestigal. The tail is of normal length but positioned too far to the right. Shell and soft part coloration fall within the range of the normal siblings. The plastral pattern is of the spotted type (figs. 1-2; see below).

The other 14 specimens are without teratological characteristics (figs. 3-6). Table 2 summarizes their body dimensions and masses at the hatching stage. As expected for hybrids, they exhibit a great variety in various character states in differing combinations, especially regarding color and pattern. Generally, the shell is more domed than in *Ch. reevesii*, somewhat resembling *C. a. kamaroma*, but with three distinct keels, in part even more pronounced than in *Ch. reevesii*. Some specimens have a more elongated shell than the others. In all turtles the plastron bears a weak anal notch. As hatchlings all hybrids were quite long-tailed, but not to the extent typically seen in *Ch. reevesii* hatchlings. To date (July 2002), all specimens have rigid plastra without any sign of an incipient plastral hinge.

Thirteen specimens resemble *C. a. kamaroma* more than *Ch. reevesii*. The color-pattern of the soft parts of another specimen (number 4) is most similar to *Ch. reevesii* (see below). This turtle is growing at a slower rate than the others (table 4).

The hatchlings had a dark brown carapace vermiculated with minute lighter elements. The three keels were of distinctly

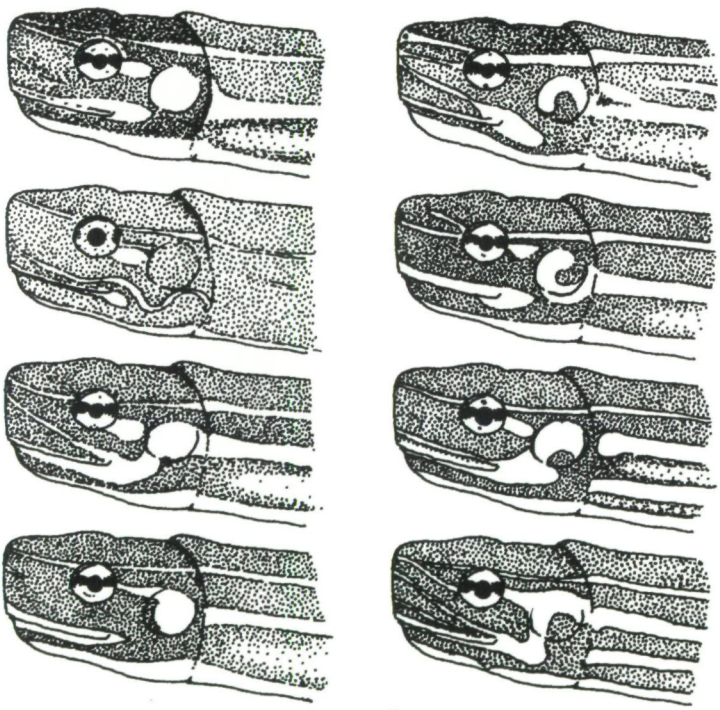


Fig. 7: Variation in head and neck pattern in hybrids between *Chinemys reevesii* and *Cuora amboinensis kamaroma* (schematic). Specimen number 4 is depicted on the left in the second row.

Abb. 7: Die Variabilität von Kopf- und Halszeichnung bei Hybriden von *Chinemys reevesii* und *Cuora amboinensis kamaroma* (schematisch). Exemplar Nummer 4 ist in der zweiten Reihe links abgebildet.

Table 3: Color-pattern and general habitus of the hybrids between *Chinemys reevesii* x *Cuora amboinensis kamaroma*. All specimens with the exception of MTD 42993 bear three distinct shell keels.

Tab. 3: Farbmuster und Gesamthabitus von Hybriden zwischen *Chinemys reevesii* x *Cuora amboinensis kamaroma*. Alle Exemplare außer MTD 42993 besitzen drei deutliche Panzerkiele.

Nr	Habitus	Plastral pattern / Plastralzeichnung	Remarks Anmerkungen
MTD 42993	aberrant	blotched / gefleckt	died immediately prior to hatching / starb unmittelbar vor d. Schlupf
1	rather like / eher wie *C. a. kamaroma*	blotched / gefleckt	-
2	rather like / eher wie *C. a. kamaroma*	uniformly dark / einheitlich dunkel	-
3	rather like / eher wie *C. a. kamaroma*	blotched / gefleckt	died 25 months after hatching / starb 25 Monate nach d. Schlupf
4	rather like / eher wie *Ch. reevesii*	uniformly dark / einheitlich dunkel	head and neck stripes distinctly thinner than in other specimens, grows clearly slower / Kopf- und Halsstreifen deutlich schmäler als bei anderen Exemplaren, wächst deutlich langsamer
5	rather like / eher wie *C. a. kamaroma*	uniformly dark / einheitlich dunkel	-
6	rather like / eher wie *C. a. kamaroma*	uniformly dark / einheitlich dunkel	-
7	rather like / eher wie *C. a. kamaroma*	uniformly dark / einheitlich dunkel	-
8	rather like / eher wie *C. a. kamaroma*	blotched / gefleckt	-
9	rather like / eher wie *C. a. kamaroma*	uniformly dark / einheitlich dunkel	-
10	rather like / eher wie *C. a. kamaroma*	uniformly dark / einheitlich dunkel	-
11	rather like / eher wie *C. a. kamaroma*	uniformly dark / einheitlich dunkel	-
12	rather like / eher wie *C. a. kamaroma*	blotched / gefleckt	-
13	rather like / eher wie *C. a. kamaroma*	blotched / gefleckt	-
14	rather like / eher wie *C. a. kamaroma*	blotched / gefleckt	-

lighter horn colour. During growth, this lighter coloration quickly disappeared. Now, the carapace has become dark brown, the keels having either the same color or being only somewhat lighter. The primary color of the soft parts is gray; the extremities and the top of the head are uniformly colored. Laterally, the head and neck are striped with yellow. With the exception of specimen number 4, these stripes are wide. This specimen has narrow light head and neck stripes, resembling the striping in *Ch. reevesii*. The primary color of its soft parts has a greenish tinge not present in the other ones.

The head pattern is quite variable (fig. 7) and can differ even in the left and right aspect of the same individual. All specimens have a mainly yellow chin and underside of the neck, patterned with some darker streaks. A yellow spot or line borders the hind margin of the orbit. The mouth is often distinctly marked with yellow. In the tympanal region of most hybrids, a prominent yellow spot or a looped line is present. The iris is greenish yellow and with the exception of specimen number 4, a black bar runs through the pupil. The tail bears two feebly defined, somewhat lighter longitudinal stripes dorsally. The plastron is mainly black in eight specimens, and resembles that of *Ch. reevesii*, whereas in seven turtles (including the malformed specimen died prior to hatching) it is blotched, similar to *C. a. kamaroma* (figs. 4 and 6; table 3). The submarginals are dark with a distinct yellow rim; the bridge is mainly dark gray to blackish. Specimens with a blotched plastron tend to have somewhat lighter submarginals and bridges than the others. On the whole, color-pattern and general habitus of the hybrids combine characters of both parental species.

The hatchlings were raised under a similar temperature regime as the adults. At the moment, 11 specimens are kept by the senior author in three small aquaria (80 cm x 40 cm x 40 cm), assorted by size. The aquaria are equipped with plastic plants, wooden roots, a basking device, and an 18 W fluorescent tube. Two specimens (numbers 5 and 8) are kept under similar conditions at the Museum für Tierkunde Dresden. Here the

Table 4: Age, body dimensions and mass of the hybrids between *Chinemys reevesii* x *Cuora amboinensis kamaroma* as measured in November 2001.

Tab. 4: Alter, Körperabmessungen und -masse der Hybriden zwischen *Chinemys reevesii* x *Cuora amboinensis kamaroma* im November 2001.

Nr	Age [months] November 2001 Alter [Monate]	Carapace length [mm] Carapaxlänge	Carapace width [mm] Carapaxbreite	Shell height [mm] Panzerhöhe	Body mass [g] Körpermasse
1	31	82	73	36	122
2	31	102	81	43	192
3 (died / verstorben)	-	-	-	-	-
4	19	50	44	25	32
5	17	60	48	28	52
6.	17	68	55	31	61
7	16	73	59	32	69
8	16	63	52	29	50
9	15	71	59	32	69
10	15	67	56	30	56
11	14	62	54	30	51
12	14	73	60	31	69
13	13	61	51	28	46
14	4	52	44	24	28

tank is equipped with a 40 W heating lamp instead of a fluorescent tube. Immediately after hatching, the water level was kept at 5 cm, later it was gradually raised to 20 cm.

The specimens are fed two to four times per week and receive the same diet as the adults.

With the exception of specimen number 3, which died after 25 months, all hybrids are in excellent condition, feeding and growing well. In November 2001, the two oldest and largest specimens measured 82 mm and 102 mm SCL and had a body mass of 122 g and 192 g, respectively (table 4).

DISCUSSION AND SOME CONSIDERATIONS ON INTERGENERIC CHELONIAN HYBRIDS

The scientific importance of chelonian hybrids has long been underestimated and we are far from a complete understanding of the mechanisms involved and the evolutionary significance of this phenomenon. Since the reviews of FRITZ & BAUR (1995) and FRITZ (1995), a number of new chelonian intergeneric hybrids has become known to science and there are rumors of other unreported cases (P. P. VAN DIJK, E. MEIER, J. F. PARHAM, pers. comm.). In addition to *Cuora serrata*, *Mauremys iversoni*, and *M. pritchardi*, several of the newly described species from South-east Asia may represent intergeneric hybrids. Many of these taxa are known exclusively from the international pet trade and not, to date, in the wild state (FRITZ & OBST 1997, 1998, 1999; ARTNER et al. 1998; LAU & SHI 2000; PARHAM et al. 2001; SHI & PARHAM 2001). Most suspicious are taxa of which only few specimens are known, namely *Ocadia glyphistoma* MCCORD & IVERSON, 1994, *O. philippeni* MCCORD & IVERSON, 1992 and *Sacalia pseudocellata* IVERSON & MCCORD, 1992. The three specimens of *S. pseudocellata* on which the description of this taxon was based considerably differed from one another (IVERSON & MCCORD 1992). Different morphs are also known from *M. iversoni* and *C. serrata* (FRITZ & OBST 1997, 1998, 1999; PARHAM et al. 2001).

Using molecular methods, three taxa have been unambiguously identified as intergeneric hybrids. PARHAM et al. (2001) revealed *Cuora serrata* to be a hybrid between female *C. galbinifrons* and male *Pyxidea mouhotii*. *Mauremys iversoni* originated from hybridization of *C. trifasciata* and *M. mutica*. In both directions, the cross-

ing produces specimens which can be regarded as "*M. iversoni*". The two specimens analyzed by WINK et al. (2001) resulted from a hybridization of a female *C. trifasciata* and a male *M. mutica*, while a turtle studied by PARHAM et al. (2001) resulted from a female *M. mutica* and a male *C. trifasciata*. Interestingly, HONDA et al. (2002) claim that "*M. iversoni*" is close to *M. annamensis* based on mitochondrial sequence data. This suggests that clearly distinct animals might be sold under the same name in the international pet trade.

WINK et al. (2001) also demonstrated the hybrid origin for *Mauremys pritchardi*. This taxon arose from crossing male *Chinemys reevesii* and female *M. mutica*. Remarkably, "*M. pritchardi*" is morphologically more homogenous than "*Cuora serrata*" or "*M. iversoni*". Moreover, M. REIMANN (pers. comm.) states that "*M. pritchardi*" has been bred to the second generation in Germany. The offspring seems to be morphologically consistent. Successful captive breeding has also occurred in two other hybrids ("*M. iversoni*": ARTNER 1995; FRITZ & OBST 1999; "*C. serrata*": FRITZ & OBST 1997; J. BARZYK, M. REIMANN pers. comm.). In another intergeneric hybrid (*Chinemys reevesii* x *Mauremys japonica*), YASUKAWA et al. (1992) reported that female hybrids produced vigorous offspring whereas the testes of male hybrids contained no spermatozoa. However, a small number of female hybrids have also "an incompletely developed reproductive anatomy in comparison to adult female *M. japonica* and *Ch. reevesii*" (YASUKAWA et al. 1992).

The hybridization of *Chinemys reevesii* and *Cuora amboinensis kamaroma* reported here provides an additional example of an intergeneric cross in geoemydid turtles producing viable offspring. Compared to "*M. pritchardi*", the hybrids between *Ch. reevesii* and *C. a. kamaroma* seem to be morphologically more variable. In this respect our hybrids resemble "*Cuora serrata*" and "*Mauremys iversoni*", and perhaps *Sacalia pseudocellata* which is suspected to be of hybrid origin as well. Morphological variability in chelonian intergeneric hybrids does not appear to follow a predictable pattern. The "*M. pritchardi*" bred in Germany exhibit no more phenotypic variation than a "normal" species, and closely resemble their parents (M. REIMANN pers. comm.).

Only one of our hybrids between *Chinemys reevesii* and *Cuora amboinensis kamaroma* was malformed. The only other intergeneric hybrid with teratological characteristics reported to date is a hybrid between *C. a. kamaroma* and *Mauremys annamensis* (FRITZ & MENDAU 2002). However, such malformed specimens are also known from many normal turtle species. For example, EWERT (1979) reports teratological findings for several North American species. Due to the restricted sample size it would be precocious to draw any conclusions about the incidence or rate of developmental disorders for chelonian hybrids. The same is true for our data on hatching success (58 % in 24 eggs).

In any case, several questions arise: (1) Do distantly related chelonian taxa also hybridize in nature? (2) If so, are the hybrids fertile, and (3) has hybridization of distantly related taxa had any evolutionary impact? (4) Can hybridization events give rise to new "hybridogenic species", as considered for "*Cuora serrata*", "*Mauremys iversoni*" and "*M. pritchardi*" by PARHAM et al. (2001) and WINK et al. (2001)? And, (5) which mechanisms (e. g., allopolyploidy) allow such hybridization events to succeed?

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