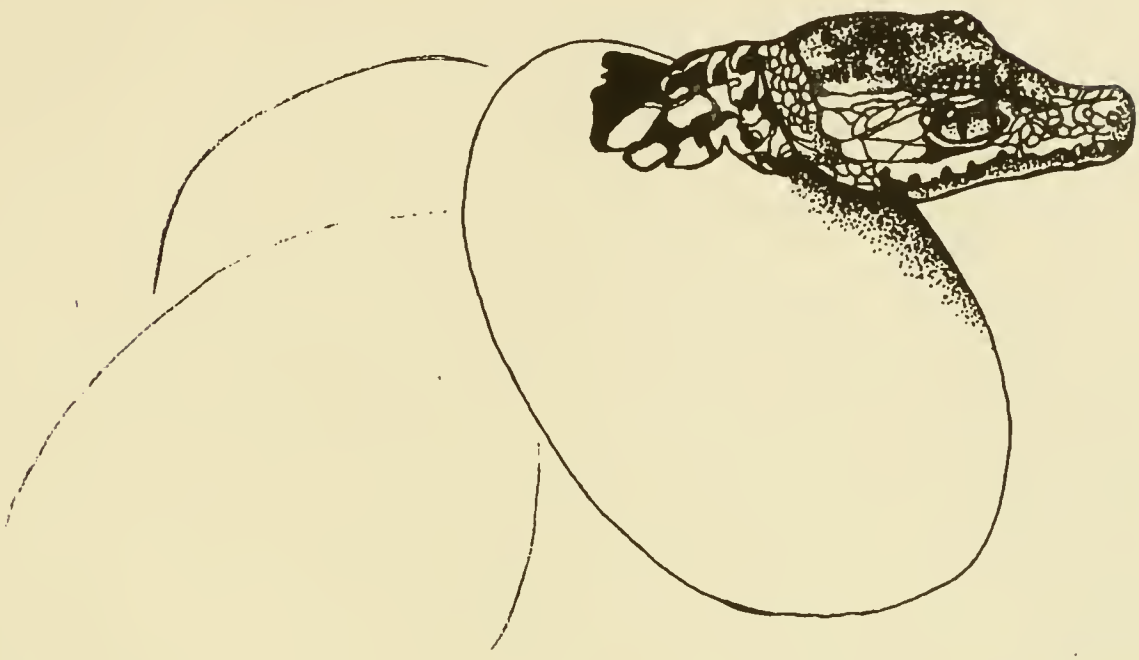
SEX DETERMINATION IN REPTILES: SUMMARY OF EFFECTS OF CONSTANT TEMPERATURES OF INCUBATION ON SEX RATIOS OF OFFSPRING



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INTRODUCTION

The phenomenon of environmental sex determination (ESD) in reptiles has been highly publicized in recent years. However, the underlying mechanism(s) that control this process are still poorly known. Additionally, the distribution of ESD within the Reptilia is poorly known, with only 93 of the approximately 6500 species of extant reptiles having been examined for the presence of ESD (Janzen and Paukstis, Quart. Rev. Biol.).

This paper provides a summary of much of the research conducted on ESD in reptiles from laboratory studies that have employed constant temperatures of incubation (Table 1). Table 1 is an extension of and appendix to a review article on ESD in reptiles (Janzen and Paukstis, Quart. Rev. Biol.). As a result of the recent proliferation of publications concerning various aspects of ESD in reptiles, this table originated as a tool to provide an overview of laboratory results that were currently available. As the data accumulated, we were impressed not by their consistency, but by the amount of variability that existed among different studies. Although each of these studies individually provided important new data on ESD, when many papers were viewed simultaneously it became very difficult to compare results.

The potential sources of this variability in sex ratios among different studies are many but, in general, fall into two broad categories--biological and artifactual. Among biological sources of variability are such factors as inter- and intrapopulational genetic differences, nongenetic maternal influences, and different regulatory mechanisms that may vary taxonomically within the Reptilia. Artifacts (nonbiological and experimental) include differences in experimental design and implementation (e.g., how closely temperature was monitored or regulated, randomization of eggs across experimental treatments, small sample sizes) and different techniques in sexing hatchlings (e.g., presence/absence of oviducts, histological confirmation).

Another factor that may reduce the value of results from some studies is the manner in which the results are presented (e.g., actual sample sizes as opposed to just the sex ratios of hatchlings, data on embryonic mortality). An additional problem is inconsistency and lack of definition of terminology. For example, what is the actual relationship between the morphology of a given gonad and the terminology used to describe it in hatchlings from different studies, when these hatchlings have been described as "hermaphrodites", "intersexes", "unsexable", or "unsexed"? Even though the answer to this question may be obvious, unless the terminology in each of these papers has been adequately defined, it is difficult to ascertain precisely how the gonads of these hatchlings may or may not differ. To properly understand ESD in reptiles, it is very important to differentiate between these biological and artificial/experimental sources of variation and to strive to minimize those sources of variation that may mask actual biological effects.

In this paper we provide a compilation of much of the published empirical research on ESD in reptiles. Specifically, we summarize information on incubation temperatures, sex ratios, and sample sizes from laboratory studies that have used constant temperatures of incubation. Comments are provided in those instances where they may lend insight into variability of sex ratios or to denote information that may be of particular interest. The arrangement of the major taxa used in Table 1 follows that of Janzen and Paukstis (Quart. Rev. Biol.). Families are listed alphabetically within the major taxa and genera are presented alphabetically within families.

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Table 1. SUMMARY OF OFFSPRING SEX RATIOS FROM STUDIES USING CONSTANT TEMPERATURES OF INCUBATION

The number of males and females presented in this table were, in some cases, calculated from percentages provided in the sources indicated. In other cases, percentages were calculated from sample sizes. Question marks (?) denote data that were not presented in the source.

Taxa	Temp (C)	Males # ♂♂ (%)	Females # ♀♀ (%)	# eggs/# clutches	Comments	Source
TESTUDINES						
CRYPTODIRA						
CARETTOCHELYIDAE						
Carettochelys insculpta						
	28	12(100)	0(0)	12/3	Eggs in 2nd group at	98
	30	20(100)	0(0)	24/5	32° were collected	
	32	0(0)	9(100)	12/3	late in development	
	32	23(50)	23(50)	46/5		
CHELONIIDAE						
Caretta caretta						
	26	20(100)	0(0)	20/5	89% hatching success	38
	32	0(0)	20(100)	20/5	83% hatching success	
	25	?(100)	0(0)	10/1		53
	26	?(100)	0(0)	10/1		
	27.5	?(80)	?(20)	10/1		
	29	?(50)	?(50)	10/1		
	30.5	0(0)	?(100)	10/1		
	32	0(0)	?(100)	10/1		
	25	8(100)	0(0)	10/1	2 unsexable	54
	25	7(100)	0(0)	10/1		
	26	16(100)	0(0)	16/2		
	26	6(67)	3(33)	10/1		
	26	10(100)	0(0)	10/1		
	26	7(88)	1(12)	10/1	1 unsexable	
	27	8(80)	2(20)	10/1		
	27	6(86)	1(14)	10/1	2 unsexable	
	27.5	5(56)	4(44)	10/1		
	27.5	3(30)	7(70)	10/1		
	27.5	8(80)	2(20)	10/1		
	28	4(44)	5(56)	10/1		
	28	2(100)	0(0)	10/1		
	29	1(11)	8(89)	10/1		

Taxa	Temp (C)	# ♂♂ (%)	# ♀♀ (%)	# eggs/# clutches	Comments	Source
	29	5(56)	4(44)	10/1		
	29	2(20)	8(80)	10/1		
	29	5(50)	5(50)	10/1		
	29	6(60)	4(40)	10/1		
	30	0(0)	7(100)	10/1		
	30	3(33)	6(67)	10/1		
	30	2(20)	8(80)	10/1		
	30.5	0(0)	1(100)	1/1		
	30.5	2(33)	4(67)	7/1		
	30.5	0(0)	10(100)	10/1		
	31	0(0)	8(100)	10/1	1 unsexable	
	31	0(0)	16(100)	20/2		
	32	0(0)	19(100)	20/2		
	32	0(0)	6(100)	10/1	1 unsexable	
	27.5	6(86)	1(14)	?/2	North Carolina (NC)	62
	28.0	26(90)	3(10)	?/2	NC	
	28.5	22(69)	10(31)	?/2	NC	
	28.5	9(33)	18(67)	?/2	Georgia (GA)	
	28.5	25(74)	9(26)	?/2	Florida (FL)	
	28.8	19(79)	5(21)	?/2	NC	
	28.8	12(34)	23(66)	?/2	GA	
	28.8	22(65)	12(35)	?/2	FL	
	29.2	4(50)	4(50)	?/2	NC	
	29.5	8(33)	16(67)	?/2	NC	
	29.5	8(20)	31(78)	?/2	GA; 1 intersex	
	29.5	12(35)	25(65)	?/2	FL	
	30.0	3(37)	5(63)	?/2	NC	
	30.4	0(0)	25(100)	?/2	GA	
	30.4	2(5)	36(92)	?/2	FL; 1 intersex	
	30.5	0(0)	23(100)	?/2	NC	
	24	11(100)	0(0)	23/3		104,105,
	26	24(100)	0(0)	26/5		106
	28	20(100)	0(0)	26/5		
	30	5(36)	9(64)	15/1	Incubated in 1978	
	30	5(56)	4(44)	15/2	Incubated in 1979	
	30	4(80)	1(20)	6/2	Incubated in 1980	
	32	0(0)	21(100)	26/5		
	34	0(0)	7(100)	26/5		
Chelonia mydas						
	26	16(84)	0(0)	20/1	3 intersexes	57
	29	0(0)	37(90)	41/1	4 intersexes	
	33	0(0)	12(86)	20/1	2 intersexes	
	27.75	19(68)	6(21)	38/3	3 intersexes	63
	28.1	17(61)	10(36)	37/3	1 intersex	
	29.25	11(35)	18(58)	38/3	2 intersexes	
	30.0	9(43)	11(52)	37/3	1 intersex	

Taxa	Temp (C)	# ♂♂ (%)	# ♀♀ (%)	# eggs/# clutches	Comments	Source
	27.5	587(~44)	763(~56)	?/?	Numbers for each	100
	27.5	1178(~27)	3181(~73)	?/?	sex are estimates	
	27.5	23(~77)	7(~23)	?/?	owing to imprecision	
	27.5	1572(~67)	786(~33)	?/?	in sex ratios given	
	27.5	237(~67)	118(~33)	?/?		
	30.0	97(~ 1)	13661(~99)	?/?		
Lepidochelys olivacea						
	26.5	?(100)	0(0)	?/1		24
	29.5	0(0)	?(100)	?/1		
	31.5	0(0)	?(100)	?/1		
	25	23(100)	0(0)	50/3		56
	28	30(88)	1(3)	50/3	3 unsexable	
	30	12(48)	8(32)	50/3	5 unsexable	
	32	0(0)	23(100)	50/3		
	26.5	?(100)	0(0)	?/>1		60
	28.0	?(100)	0(0)	?/>1		
	29.5	?(40)	?(60)	?/>1		
	30.0	0(0)	?(100)	?/>1		
	31.0	0(0)	?(100)	?/>1		
	31.5	0(0)	?(100)	?/>1		
	27.5	?(100)	0(0)	?/?		61
	29.5	?(?)	?(?)	?/?	Both sexes produced	
	31.5	0(0)	?(100)	?/?		
	25.7	160(98)	1(1)	?/9	3 intersexes	84
	~27.4	59(98)	1(2)	?/3		
CHELYDRIDAE						
Chelydra serpentina						
	25	10(100)	0(0)	10/?		21
	30	0(0)	11(100)	11/?		
	28.5	?(?)	?(?)	?/?	Both sexes produced	22
	31	0(0)	4(80)	5/?	1 intersex	
	26.0	7(88)	1(12)	?/2	44 eggs incubated	23
	28.5	3(23)	10(77)	?/2	in total for this	
	31.0	0(0)	13(100)	?/2	experiment	
	21.5	2(25)	6(75)	?/?	Indiana	28
	21.5	0(0)	3(100)	?/?	Tennessee	
	22.5	5(50)	5(50)	?/?	Indiana	
	22.5	32(94)	2(6)	?/?	Minnesota	
	25	33(92)	3(8)	36/?		33
	31	0(0)	33(100)	33/?		

Taxa	Temp (C)	# ♂♂ (%)	# ♀♀ (%)	# eggs/# clutches	Comments	Source
	26	36(95)	2(5)	?/?		34
	23	54(100)	0(0)	54/9		42,43
	26	50(100)	0(0)	50/9		
	29	0(0)	63(100)	63/15		69
	20	0(0)	21(100)	85/5	Eggs in the two 20°	102
	20	0(0)	37(100)	66/2	treatments were	
	22	19(90)	2(10)	21/3	switched to 26°	
	24	18(100)	0(0)	18/3	after 88 days and	
	26	108(100)	0(0)	132/16	83 days, respectively	
	26	79(98)	2(2)	91/7		
	28	17(65)	9(35)	27/3		
	30	0(0)	5(100)	23/5		
	30	0(0)	48(100)	72/6		
	30	0(0)	34(100)	56/5		
	20	0(0)	149(100)	245/?	Eggs in the 20°	103
	26	373(99)	3(1)	431/?	treatment completed	
	30	0(0)	142(100)	196/?	incubation at 26°	
Macroclemys temmincki						
	25	?(60)	?(40)	?/?		6
	31	0(0)	?(100)	?/?		
	22.5	2(11)	16(89)	?/?		28
	25	9(69)	4(31)	?/?		
	27	10(71)	4(29)	?/?		
	30	0(0)	11(100)	?/?		
DERMOCHELYIDAE						
Dermochelys coriacea						
	27.4	50(100)	0(0)	50/5	Temps measured every	25
	28.1	50(100)	0(0)	50/5	2-5 days at 0700 &1800	
	27	?(100)	0(0)	~25/1		52
	~28	?(100)	0(0)	~25/1		
	~29	?(100)	0(0)	~25/1		
	31	0(0)	40(100)	40/?		
	27	33(100)	0(0)	75/2		79
	27.25	5(100)	0(0)	11/1		
	28	4(100)	0(0)	38/2		
	28.25	1(100)	0(0)	10/1		
	28.75	15(100)	0(0)	51/2		
	29.75	0(0)	4(100)	11/1		
	30.5	0(0)	18(100)	59/3		
	32	0(0)	3(100)	35/2		

Taxa	Temp (C)	# ♂♂ (%)	# ♀♀ (%)	# eggs/# clutches	Comments	Source
	29.25	9(100)	0(0)	140/4		80
	29.5	1(25)	3(75)	16/1		
	29.5	12(86)	2(14)	16/1		
	29.75	0(0)	32(100)	68/2		
EMYDIDAE						
Batagurinae						
Chinemys reevesii						
	~25	18(100)	0(0)	25/?		40
	32	0(0)	12(92)	25/?	1 intersex	
Mauremys mutica						
	25	3(75)	1(25)	?/?		28
	30	0(0)	9(100)	?/?		
Melanochelys trijuga						
	23.8	0(0)	2(100)	?/?		28
	25	7(23)	23(77)	?/?		
	27	15(56)	12(44)	?/?		
	30	1(3)	31(97)	?/?		
Rhinoclemmys areolata						
	25	6(100)	0(0)	?/?		28
	30	0(0)	6(100)	?/?		
Rhinoclemmys pulcherrima						
	25	14(100)	0(0)	?/?		28
	30	2(25)	6(75)	?/?		
Emydinae						
Chrysemys picta						
	25	81(100)	0(0)	102/?		11
	30.5	0(0)	81(100)	101/?		
	28.0	1(2)	40(98)	41/>10	Tennessee (TN)	13
	28.0	92(98)	2(2)	94/>25	Wisconsin (WI)	
	28.3	1(9)	10(91)	11/>10	TN	
	29.0	0(0)	12(100)	12/>10	TN	
	29.0	24(63)	14(37)	38/>25	WI	
	29.5	0(0)	5(100)	5/>10	TN	
	29.5	0(0)	7(100)	7/>25	WI	
	30.0	0(0)	16(100)	16/>10	TN	
	30.0	0(0)	56(100)	56/>25	WI	
	30.6	0(0)	14(100)	14/>10	TN	
	30.6	0(0)	22(100)	22/>25	WI	
	28.5	0(0)	?(100)	?/?		22
	31	0(0)	?(100)	?/?		

Taxa	Temp (C)	# ♂♂ (%)	# ♀♀ (%)	# eggs/# clutches	Comments	Source
	26.0	7(100)	0(0)	?/7		23
	28.5	0(0)	16(100)	?/7		
	31.0	0(0)	18(100)	?/7		
	21.5	102(100)	0(0)	?/?	some feminization	28
	22.5	10(100)	0(0)	?/?		
	25	83(100)	0(0)	?/?		
	27	33(100)	0(0)	?/?		
	30	0(0)	78(100)	?/?		
	25	23(100)	0(0)	23/?		33
	31	0(0)	28(100)	28/?		
	26.5	19(100)	0(0)	19/?		36
	26.5	28(80)	7(20)	35/?		
	27	21(100)	0(0)	30/?	9 unsexable	
	27	6(43)	8(57)	18/?	4 unsexable	
	28.5	4(19)	17(81)	21/?		
	28.5	3(14)	18(86)	21/?		
	28.5	7(78)	2(22)	9/?		
	28.5	6(75)	2(25)	8/?		
	30.5	0(0)	37(100)	37/?		
	32	0(0)	14(100)	15/?	1 unsexable	
	22	6(35)	11(65)	40/21	1 unsexable	37
	27	21(100)	0(0)	31/21	9 unsexable	
	32	0(0)	14(100)	31/21	1 unsexable	
	25.7	41(100)	0(0)	45/24	-150 and -1100 kPa	68
	26.7	38(100)	0(0)	45/24	-150 and -1100 kPa	
	27.7	29(100)	0(0)	45/24	-150 and -1100 kPa	
	28.7	13(68)	6(32)	21/12	-150 kPa	
	28.7	7(50)	6(43)	24/12	-1100 kPa, 1 intersex	
	20	3(50)	3(50)	21/19		83
	22	14(100)	0(0)	20/19		
	24	17(100)	0(0)	21/19		
	26	18(100)	0(0)	21/19		
	28	3(19)	13(81)	21/19		
	30	0(0)	19(100)	21/19		
	32	0(0)	17(100)	21/19		
Clemmys guttata						
	22.5	10(91)	1(9)	?/?		28
	25	14(70)	6(30)	?/?		
	27	12(92)	1(8)	?/?		
	30	0(0)	19(100)	?/?		
Clemmys insculpta						
	25	6(33)	12(67)	18/6		10
	30	7(39)	11(61)	18/6		

Taxa	Temp (C)	# ♂♂ (%)	# ♀♀ (%)	# eggs/# clutches	Comments	Source
	22.5	15(44)	19(56)	?/?		28
	25	19(44)	24(56)	?/?		
	27	15(44)	19(56)	?/?		
	30	24(53)	21(47)	?/?		
Clemmys muhlenbergii						
	25	1(33)	2(67)	?/?		28
Deirochelys reticularia						
	25	16(100)	0(0)	?/?		28
	30	2(11)	17(89)	?/?		
Emydoidea blandingii						
	22.5	40(100)	0(0)	?/?		28
	25	57(97)	2(3)	?/?		
	30	0(0)	63(100)	?/?		
	26.5	10(100)	0(0)	?/6		35
	31.0	0(0)	10(100)	?/6		
Emys orbicularis						
	30	1(4)	23(96)	24/?		71
	25	40(100)	0(0)	40/?		72
	29.5	0(0)	11(100)	11/?		
	27.5	25(100)	0(0)	25/?		73
	25	76(100)	0(0)	76/?		74
	27.5	25(100)	0(0)	25/?		
	29.5	0(0)	117(100)	117/?		
	27.75	30(100)	0(0)	30/?		75
	28.25	19(95)	1(5)	20/?		
	28.75	8(42)	11(58)	19/?		
	29.25	1(3)	29(94)	31/?	1 intersex	
	27.75	23(77)	0(0)	30/?	7 intersexes	76
	28.25	20(54)	4(11)	37/?	13 intersexes	
	28.75	6(18)	13(39)	33/?	14 intersexes	
	29.25	0(0)	29(94)	31/?	2 intersexes	
	29.75	0(0)	54(100)	54/?		
	18	8(100)	0(0)	8/?		77
	19.5	6(100)	0(0)	6/?		
	35	0(0)	10(100)	10/?		
	25.5	149(100)	0(0)	149/?		107
	28.75	6(16)	30(81)	37/?	1 intersex	
	30.25	0(0)	127(100)	127/?		

Taxa	Temp (C)	# ♂♂ (%)	# ♀♀ (%)	# eggs/# clutches	Comments	Source
	28.5	1(11)	8(89)	9/1		108
	28.5	0(0)	10(100)	10/1		
	28.5	0(0)	5(63)	8/1	3 intersexes	
	28.5	4(80)	1(20)	6/1	1 embryo died	
	28.5	4(67)	1(17)	6/1	1 intersex	
	28.5	4(44)	1(11)	9/1	4 intersexes	
	28.5	2(18)	9(82)	11/1		
	28.5	1(14)	6(86)	7/1		
	28.5	5(83)	1(17)	7/1	1 egg unfertilized	
	28.5	1(10)	6(60)	10/1	3 intersexes	
Graptemys barbouri						
	25	9(100)	0(0)	?/?		28
	30	0(0)	9(100)	?/?		
Graptemys geographica						
	25	98(100)	0(0)	122/?		11
	30.5	0(0)	88(100)	119/?		
	28.0	26(100)	0(0)	26/7		13
	29.0	2(33)	4(67)	6/7		
	30.0	0(0)	28(100)	28/7		
	22.5	14(100)	0(0)	?/?		28
	25	33(100)	0(0)	?/?		
	27	22(100)	0(0)	?/?		
	30	0(0)	44(100)	?/?		
	33	0(0)	3(100)	?/?		
Graptemys kohnii						
	25	151(100)	0(0)	?/?		28
	30	0(0)	153(100)	?/?		
Graptemys nigrinoda						
	25	6(100)	0(0)	?/?		28
	30	0(0)	7(100)	?/?		
Graptemys ouachitensis						
	25	210(100)	0(0)	233/?		11
	30.5	0(0)	211(100)	237/?		
	29.25	3(30)	7(70)	10/1		12
	29.25	7(78)	2(22)	10/1		
	29.25	4(40)	6(60)	10/1		
	29.25	4(50)	3(38)	10/1	1 intersex	
	29.25	2(22)	7(78)	10/1		
	29.25	5(50)	4(40)	10/1	1 intersex	
	29.25	0(0)	9(100)	10/1		
	29.25	7(78)	2(22)	10/1		
	29.25	0(0)	10(100)	10/1		
	29.25	1(10)	9(90)	10/1		

Taxa	Temp (C)	# ♂♂ (%)	# ♀♀ (%)	# eggs/# clutches	Comments	Source
	29.25	9(90)	0(0)	10/1	1 intersex	
	29.25	2(22)	7(78)	10/1		
	29.25	3(30)	7(70)	10/1		
	29.25	4(44)	5(56)	10/1		
	29.25	10(100)	0(0)	10/1		
	29.25	4(40)	6(60)	10/1		
	29.25	4(40)	5(50)	10/1	1 intersex	
	29.25	1(10)	9(90)	10/1		
	29.25	3(30)	6(60)	10/1	1 intersex	
	29.25	5(50)	5(50)	10/1		
	28.0	93(100)	0(0)	93/>25		13
	29.0	53(83)	11(17)	64/>25		
	30.0	1(1)	88(99)	89/>25		
	25	69(100)	0(0)	?/?		28
	30	0(0)	64(100)	?/?		
Graptemys pseudogeographica						
	25	173(100)	0(0)	222/?		11
	30.5	4(3)	147(97)	232/?		
	28.0	7(100)	0(0)	7/7	Tennessee (TN)	13
	28.0	70(100)	0(0)	70/9	Wisconsin (WI)	
	28.3	24(96)	1(4)	25/7	TN	
	28.3	14(100)	0(0)	14/9	WI	
	29.0	0(0)	5(100)	5/7	TN	
	29.0	22(92)	2(8)	24/9	WI	
	29.3	13(28)	34(72)	47/7	TN	
	29.3	33(58)	24(42)	57/9	WI	
	29.5	4(16)	21(84)	25/7	TN	
	29.5	5(33)	10(67)	15/9	WI	
	30.0	0(0)	5(100)	5/7	TN	
	30.0	9(11)	73(89)	82/9	WI	
	30.6	0(0)	22(100)	22/7	TN	
	30.6	0(0)	17(100)	17/9	WI	
	22.5	11(100)	0(0)	?/?		28
	25	16(100)	0(0)	?/?		
	30	0(0)	14(100)	?/?		
	33	0(0)	11(100)	?/?		
	25	54(100)	0(0)	66/17	Eggs from *ouachitensis*	92
	35	0(0)	17(100)	70/17	and *pseudogeographica*	
Graptemys pulchra						
	28.0	17(100)	0(0)	17/>10		13
	29.0	0(0)	4(100)	4/>10		
	30.0	0(0)	14(100)	14/>10		

Taxa	Temp (C)	# ♂♂ (%)	# ♀♀ (%)	# eggs/# clutches	Comments	Source
Malaclemys terrapin						
	24	20(100)	0(0)	?/?		28
	30	0(0)	34(100)	?/?		
	27	2(67)	1(33)	7/1	1972	82
	27	35(100)	0(0)	63/9	1973-1975	
	27	7(88)	1(12)	8/1	1977	
	27	8(100)	0(0)	9/1	1977	
Pseudemys concinna						
	22.5	13(100)	0(0)	?/?		28
	25	52(91)	5(9)	?/?		
	30	0(0)	55(100)	?/?		
Pseudemys floridana						
	25	4(100)	0(0)	?/?		28
	30	0(0)	4(100)	?/?		
Terrapene carolina						
	26.0	3(50)	3(50)	?/5		23
	28.5	2(40)	3(60)	?/5		
	31.0	1(14)	6(86)	?/5		
	21.5	13(93)	1(7)	?/?		28
	22.5	24(73)	9(27)	?/?		
	25	73(96)	3(4)	?/?		
	27	25(81)	6(19)	?/?		
	30	0(0)	84(100)	?/?		
Terrapene ornata						
	21.5	1(100)	0(0)	?/?		28
	22.5	14(100)	0(0)	?/?		
	25	8(100)	0(0)	?/?		
	29	0(0)	28(100)	31/9	2 unsexed	70
Trachemys scripta						
	28.0	21(100)	0(0)	21/>10	Alabama (AL)	13
	28.3	33(92)	3(8)	36/>10	Tennessee (TN)	
	29.0	6(38)	10(62)	16/>10	AL	
	29.5	12(30)	28(70)	40/>10	TN	
	30.0	0(0)	17(100)	17/>10	AL	
	30.6	2(5)	40(95)	42/>10	TN	
	21.5	3(100)	0(0)	?/?		28
	22.5	23(100)	0(0)	?/?		
	25	21(100)	0(0)	?/?		
	27	3(100)	0(0)	?/?		
	30	0(0)	20(100)	?/?		

Taxa	Temp (C)	# ♂♂ (%)	# ♀♀ (%)	# eggs/# clutches	Comments	Source
KINOSTERNIDAE						
Kinosternon flavescens						
	25	5(33)	10(67)	?/?		28
	27	13(93)	1(7)	?/?		
	30	10(91)	1(9)	?/?		
	32	0(0)	8(100)	?/?		
	25	11(79)	3(21)	29/10		94
	31	0(0)	16(100)	27/10		
	25	?(79)	?(21)	?/?	*K. flavescens*?	6
	31	0(0)	?(100)	?/?		
Kinosternon leucostomum						
	22.5	1 or 2(19)	6 or 7(81)	?/?		28
	24	1(100)	0(0)	?/?		
	25	3(75)	1(25)	?/?		
	27	0(0)	6(100)	?/?		
	30	0(0)	9(100)	?/?		
Kinosternon scorpioides						
	22.5	8(22)	14(78)	?/?		28
	24	25(82)	6(18)	?/?		
	25	53(81)	12(19)	?/?		
	27	23(70)	10(30)	?/?		
	30	0(0)	73(100)	?/?		
Kinosternon subrubrum						
	22.5	1(17)	5(83)	?/?		28
Sternotherus carinatus						
	22.5	0(0)	5(100)	?/?		28
	25	1(20)	4(80)	?/?		
	27	6(100)	0(0)	?/?		
	30	0(0)	6(100)	?/?		
Sternotherus minor						
	22.5	1(4)	27(96)	?/?		28
	24	1(8)	11(92)	?/?		
	25	22(76)	7(24)	?/?		
	27	1(6)	17(94)	?/?		
	30	0(0)	36(100)	?/?		
	32	0(0)	3(100)	?/?		
Sternotherus odoratus						
	21.5	0(0)	14(100)	?/?		28
	22.5	0(0)	59(100)	?/?		
	23.8	8(31)	18(69)	?/?		
	25	46(94)	3(6)	?/?		
	27	6(23)	20(77)	?/?		

Taxa	Temp (C)	# ♂♂ (%)	# ♀♀ (%)	# eggs/# clutches	Comments	Source
	30	0(0)	51(100)	?/?		
	23.5	6(19)	26(81)	34/20		94
	25	27(82)	6(18)	34/20		
	28	2(3)	68(97)	92/58		
	29.5	2(3)	56(97)	58/38		
	30.5	1(2)	40(98)	69/58		
STAUROTYPIDAE						
Staurotypus salvinii						
	22.5	1(25)	4(75)	?/?	from 1 female	28
	22.5	18(100)	0(0)	?/?	from 3 females	
	25	8(53)	7(47)	?/?	from 1 female	
	25	19(100)	0(0)	?/?	from 3 females	
	27	3(60)	2(40)	?/?	from 1 female	
	27	14(100)	0(0)	?/?	from 3 females	
	30	3(33)	6(67)	?/?	from 1 female	
	30	7(78)	2(22)	?/?	from 3 females	
Staurotypus triporcatus						
	22.5	11(44)	14(56)	?/?		28
	25	17(55)	14(45)	?/?		
	27	12(40)	18(60)	?/?		
	30	8(53)	7(47)	?/?		
TESTUDINIDAE						
Testudo graeca						
	26.5	19(100)	0(0)	19/?		71
	30	22(96)	1(4)	23/?		
	31	0(0)	20(100)	20/?		72
	33	0(0)	20(100)	20/?		
	26.5	19(100)	0(0)	19/?		74
	29.5	37(97)	1(3)	38/?		
	31.5	0(0)	16(100)	16/?		
Testudo hermanni						
	~23.5	6(100)	0(0)	6/1		26
TRIONYCHIDAE						
Trionyx muticus						
	27	23(44)	29(56)	?/?		28
	30	26(49)	27(51)	?/?		
	33	30(54)	25(46)	?/?		
Trionyx spiniferus						
	31	7(50)	7(50)	51/?		9

Taxa	Temp (C)	# ♂♂ (%)	# ♀♀ (%)	# eggs/# clutches	Comments	Source
	25	33(49)	34(51)	83/?		11
	30.5	27(53)	24(47)	86/?		
	23	7(41)	10(59)	68/?	51 unsexed	93
	25	34(49)	35(51)	86/?	17 unsexed	
	28	29(52)	27(48)	69/?	13 unsexed	
	30.5	28(53)	25(47)	89/?	36 unsexed	
	33	21(41)	30(59)	66/?	15 unsexed	
PLEURODIRA						
CHELIDAE						
Chelodina longicollis						
	24	7(35)	13(65)	25/15	5 unsexed	31
	26	4(36)	7(64)	13/13	2 unsexed	
	28	4(31)	9(69)	13/13		
	30	6(35)	11(65)	18/15	1 unsexed	
	32	14(64)	11(36)	27/15	1 unsexed	
Emydura macquarii						
	20	1(33)	2(67)	6/1	Eggs at 20° were	85,86
	~25	13(65)	7(35)	24/8	switched to 30°	
	26	7(37)	12(63)	24/8	after 91 days	
	28	10(50)	10(50)	24/8		
	30	18(78)	5(22)	24/8		
	30	58(52)	53(48)	?/?		
	32	10(56)	8(44)	24/8		
Emydura signata						
	25	15(45)	18(55)	33/12		10
	28	3(25)	9(75)	12/12		
	30	13(65)	7(35)	20/12		
PELOMEDUSIDAE						
Pelomedusa subrufa						
	24	0(0)	2(100)	?/?		28
	25	0(0)	11(100)	?/?		
	27	0(0)	17(100)	?/?		
	30	12(71)	5(29)	?/?		
	33	0(0)	9(100)	?/?		
Pelusios castaneus						
	25	0(0)	11(100)	?/?		28
	27	0(0)	3(100)	?/?		
	30	14(82)	3(18)	?/?		
	33	0(0)	5(100)	?/?		

Taxa	Temp (C)	# ♂♂ (%)	# ♀♀ (%)	# eggs/# clutches	Comments	Source
CROCODYLIA						
ALLIGATORIDAE						
Alligator mississippiensis						
	32	12(100)	0(0)	46/?		9
	26	0(0)	10(100)	50/13		29,30
	28	0(0)	96(100)	100/13		
	30	0(0)	97(100)	100/13		
	32	13(13)	85(87)	100/13		
	34	94(100)	0(0)	100/13		
	36	7(100)	0(0)	50/13		
	29.4	0(0)	90(100)	113/11		44,45
	30.6	13(41)	19(59)	42/11		
	31.7	41(75)	14(25)	67/11		
	32.8	111(99)	1(1)	135/11		
	30	0(0)	?(100)	?/?		48
Caiman crocodilus						
	28.5	0(0)	?(100)	?/?		49
	~28.9	0(0)	?(100)	?/?		
	~30.1	0(0)	?(100)	?/?		
	~30.9	0(0)	?(100)	?/?		
	~31.4	?(~60)	?(~40)	?/?		
	~31.9	?(100)	0(0)	?/?		
	~32.3	?(100)	0(0)	?/?		
	33.0	?(100)	0(0)	?/?		
	33.5	?(100)	0(0)	?/?		
Paleosuchus trigonatus						
	≤31	0(0)	?(100)	?/?		101
	32	?(100)	0(0)	?/?		
CROCODYLIDAE						
Crocodylus johnsoni						
	28.0	0(0)	4(100)	?/?	Incubation method A	96
	29.0	0(0)	31(100)	?/?	A & B	
	30.0	0(0)	48(100)	?/?	A & B	
	31.0	0(0)	9(100)	?/?	A	
	31.0	2(13)	14(87)	?/?	B	
	31.5	7(23)	24(77)	?/?	B	
	31.7	5(25)	15(75)	?/?	A	
	32.0	4(31)	9(69)	?/?	A	
	32.0	0(0)	14(100)	?/?	B	
	32.5	6(23)	20(77)	?/?	A	
	32.5	0(0)	6(100)	?/?	B	
	33.0	0(0)	27(100)	?/?	A & B	

Taxa	Temp (C)	# ♂♂ (%)	# ♀♀ (%)	# eggs/# clutches	Comments	Source
	34.0	0(0)	9(100)	?/?	A	
	26	0(0)	12(100)	122/?		97
	27.9	0(0)	15(100)	44/?		
	29.9	0(0)	48(100)	70/?		
	30	5(19)	21(81)	41/?	1 clutch gave 12 females, 2 dead	
	30	1(1)	123(99)	176/?	The male was deformed	
	31.1	3(13)	20(87)	28/?		
	31.7	0(0)	5(100)	6/?		
	32.0	0(0)	13(100)	26/?		
	32.0	6(30)	14(70)	33/?		
	34	0(0)	41(100)	131/?	Most dead	
	32	5(29)	12(71)	?/?		99
	33	5(20)	20(80)	?/?		
Crocodylus niloticus						
	27.83	0(0)	82(100)	98/9		41
	30.96	0(0)	94(100)	118/10		
	32.5	10(91)	1(9)	18/1		
	33.83	53(100)	0(0)	60/6		
	33.83	9(82)	2(18)	18/1		
	33.83	6(75)	2(25)	8/1		
	33.83	11(85)	2(15)	13/1		
	33.83	3(33)	6(67)	13/1		
Crocodylus palustris						
	28	0(0)	27(100)	?/6	>90% hatching in all	49
	28.5	0(0)	35(100)	?/4	treatments except for	
	29	0(0)	32(100)	?/6	33.5° and 34°	
	29.5	0(0)	22(100)	?/4		
	30	0(0)	46(100)	?/8		
	30.5	0(0)	17(100)	?/3		
	31	0(0)	51(100)	?/6		
	31.5	2(22)	7(78)	?/1		
	32	7(70)	3(30)	?/1		
	32	2(25)	6(75)	?/1		
	32	9(69)	4(31)	?/1		
	32	1(100)	0(0)	?/1		
	32.5	8(100)	0(0)	?/1		
	33	3(21)	11(79)	?/1		
	33	3(75)	1(25)	?/1		
	33	3(27)	8(73)	?/1		
	33.5	0(0)	0(0)	19/?		
	34	0(0)	0(0)	4/?		
Crocodylus porosus						
	30	0(0)	?(100)	?/?		46
	32	?(100)	0(0)	?/?		
	28.0	0(0)	4(100)	?/?	Incubation method A	96

Taxa	Temp (C)	# ♂♂ (%)	# ♀♀ (%)	# eggs/# clutches	Comments	Source
	29.0	0(0)	26(100)	?/?	B	
	30.0	0(0)	70(100)	?/?	A & B	
	31.0	1(50)	1(50)	?/?	A	
	31.0	2(12)	15(88)	?/?	B	
	32.0	10(91)	1(9)	?/?	A	
	32.0	52(85)	9(15)	?/?	B	
	33.0	4(100)	0(0)	?/?	A	
	33.0	1(4)	25(96)	?/?	B	
Crocodylus siamensis						
	28	0(0)	?(100)	?/?		47
	32.5	?(100)	0(0)	?/?		
	27.75	0(0)	11(100)	11/1		48
	33.0	14(100)	0(0)	14/1		
SQUAMATA						
LACERTILIA						
AGAMIDAE						
Agama agama						
	26.5	1(2)	45(98)	?/?		19
	29	30(100)	0(0)	?/?		
Agama caucasia						
	27	21(72)	8(28)	44/5		50
	28	19(95)	1(5)	20/2		
ANGUIDAE						
Elgaria multicarinatus						
	27.5	?(>50)	?(<50)	?/?		51
GEKKONIDAE						
Eublepharis macularius						
	26	0(0)	20(100)	20/?		7,8
	32.5	24(80)	6(20)	30/?		
	29.5	?(50)	?(50)	?/?		8
	31.5	16(84)	3(16)	19/?		9
	31.5	13(93)	1(7)	24/?		
	26.7	?(0)	?(100)	?/?		58
	32.2	?(100)	?(0)	?/?		
	27	?(<<50)	?(>>50)	?/?		87

Taxa	Temp (C)	# ♂♂ (%)	# ♀♀ (%)	# eggs/# clutches	Comments	Source
	24	0(0)	7(100)	10/?		95
	27.85	1(2)	44(98)	59/?		
	32.7	14(88)	2(12)	18/?		
Gekko japonicus						
	20	0(0)	0(0)	20/?		88,89,90
	24	1(7)	13(93)	26/?		
	26	4(22)	19(78)	?/?		
	28	15(75)	5(25)	30/?		
	30	4(22)	19(78)	?/?		
	32	5(24)	16(76)	35/?		
Hemitheconyx caudicinctus						
	28.6	?(0)	?(100)	?/?		1
	31.7	?(100)	?(0)	?/?		
	26.7	?(0)	?(100)	?/?		58
	32.2	?(100)	?(0)	?/?		
	??	0(0)	?(100)	?/?		95
Tarentola boettgeri						
	28.5	0(0)	23(100)	?/?		65
Tarentola mauritanica						
	28.5	0(0)	33(100)	?/?		65
IGUANIDAE						
Anolis carolinensis						
	24	?(~50)	?(~50)	?/?		91
	25	?(~50)	?(~50)	?/?		
	27	?(~50)	?(~50)	?/?		
	28	?(~50)	?(~50)	?/?		
	30	?(~50)	?(~50)	?/?		
	32	?(~50)	?(~50)	?/?		
	34	?(~50)	?(~50)	?/?		
Dipsosaurus dorsalis						
	28	1(50)	1(50)	11/?		64
	30	6(35)	11(65)	22/?		
	32	6(46)	7(54)	16/?		
	34	12(75)	4(25)	21/?		
	35	0(0)	4(100)	4/?		
	36	38(49)	41(51)	94/?		
	38	7(32)	15(68)	22/?		
	40	0(0)	3(100)	4/?		
Sceloporus jarrovi						
	26	14(37)	24(63)	?/?		3
	28	28(70)	12(30)	?/?		

Taxa	Temp (C)	# ♂♂ (%)	# ♀♀ (%)	# eggs/# clutches	Comments	Source
	30	40(50)	40(50)	?/?		
	32	51(49)	53(51)	?/?		
	34	46(46)	54(54)	?/?		
	36	34(65)	18(35)	?/?		
Sceloporus undulatus						
	30	19(53)	17(47)	37/8		81
	24	?(~50)	?(~50)	?/?		91
	25	?(~50)	?(~50)	?/?		
	27	?(~50)	?(~50)	?/?		
	28	?(~50)	?(~50)	?/?		
	30	?(~50)	?(~50)	?/?		
	32	?(~50)	?(~50)	?/?		
	34	?(~50)	?(~50)	?/?		
LACERTIDAE						
Lacerta viridis						
	29	?(~50)	?(~50)	?/?		27
	17.5	6(67)	3(33)	23/~3	First 5-7 days at 25 C	78
	19.5	4(57)	3(43)	24/~3	First 13 days at 25 C	
	35.5	11(55)	9(45)	?/3	First 5-6 days at 25 C	
	35.5	4(33)	8(67)	?/2	First 13-14 days at 25 C	
Podarcis pityusensis						
	29	?(~8)	?(~92)	?/?	97% hatch success	27
TEIIDAE						
Cnemidophorus inornatus						
	25	12(55)	10(45)	22/?		20
	30	10(50)	10(50)	20/?		
Cnemidophorus uniparens						
	25	0(0)	78(100)	78/?	parthenogenetic	20
	26	0(0)	32(100)	32/?		
	29	0(0)	52(100)	52/?		
	30	0(0)	38(100)	38/?		
	31	0(0)	44(100)	44/?		
	33	0(0)	0(0)	5/?		
SERPENTES						
COLUBRIDAE						
Boiga dendrophila						
	29.25	4(50)	4(50)	9/1		2
	30	3(60)	2(40)	7/1		

Taxa	Temp (C)	# ♂♂ (%)	# ♀♀ (%)	# eggs/# clutches	Comments	Source
Cemophora coccinea						
	25	5(71)	2(29)	7/1		5
Clelia clelia						
	27	6(67)	3(33)	10/1		55
Coluber constrictor						
	26.5	7(78)	2(22)	14/1		32
Nerodia fasciata						
	21.65	99(55)	81(45)	?/10		67
	26.4	135(48)	144(52)	?/12		
	30.0	101(46)	119(54)	?/11		
Pituophis melanoleucus						
	21	1(11)	8(89)	19/?	Moved to 23° after 70 days	14
	23	20(35)	37(65)	73/?	Sexed embryos excluded	
	23	24(41)	35(59)	66/?		
	26	17(46)	20(54)	43/?		
	28	34(50)	34(50)	73/?		
	28	47(49)	49(51)	97/?		
	30	18(47)	20(53)	39/?		
	32	28(58)	20(42)	62/?		
	33	31(55)	25(45)	64/?		
Xenocalamus bicolor						
	31	2(50)	2(50)	4/1		4
ELAPIDAE						
Acanthophis antarcticus						
	29	9(45)	11(55)	20/1		39
	29	8(42)	11(58)	19/1		
	29	9(47)	10(53)	19/1		
	29	12(50)	12(50)	25/1		
	29	8(40)	12(60)	20/1		
	29	10(48)	11(52)	21/1		
	29	10(43)	13(57)	23/1		
	29	8(47)	9(53)	17/1		
Pseudechis australis						
	28	11(79)	3(21)	15/1		16
	27	6(55)	5(45)	15/1	Female #1	59
	27	8(67)	4(33)	14/1	"	
	27	9(90)	1(10)	12/1	Female #2	
Pseudechis colletti						
	28	13(81)	3(19)	18/1		16
	28	4(36)	7(64)	12/1		

Taxa	Temp (C)	# ♂♂ (%)	# ♀♀ (%)	# eggs/# clutches	Comments	Source
	28.5	2(40)	3(60)	7/1		18
Pseudechis guttatus						
	28	5(50)	5(50)	10/1		16
	28	5(63)	3(37)	8/1		
Pseudolaticauda semifasciata						
	28	51(61)	32(39)	114/29		66
PYTHONIDAE						
Aspidites melanocephalus						
	30	2(25)	6(75)	8/1		17
Morelia amethistina						
	30	3(43)	4(57)	7/1		17
Morelia spilota						
	30	11(52)	10(48)	23/1		17
	30	5(100)	0(0)	7/1		
VIPERIDAE						
Crotalus vegrandis						
	28	5(63)	3(37)	8/1		15

SOURCES--1: Anderson and Oldham (1988), 2: Bakken and Bakken (1988), 3: Beuchat (1988), 4: Branch and Patterson (1976), 5: Braswell and Palmer (1984), 6: Bull (1980), 7: Bull (1987a), 8: Bull (1987b), 9: Bull et al. (1988), 10: Bull et al. (1985), 11: Bull and Vogt (1979), 12: Bull et al. (1982a), 13: Bull et al. (1982b), 14: Burger and Zappalorti (1988), 15: Carl et al. (1982), 16: Charles (1988), 17: Charles et al. (1985), 18: Charles et al. (1983), 19: Charnier (1966), 20: Crews (1989), 21: Crews et al. (1989), 22: Dimond (1979), 23: Dimond (1983), 24: Dimond and Mohanty-Hejmadi (1983), 25: Dutton et al. (1985), 26: Ehrengart (1971), 27: Eichenberger (1981), 28: Ewert and Nelson (in press), 29: Ferguson and Joanen (1982), 30: Ferguson and Joanen (1983), 31: Georges (1988), 32: Gillingham (1976), 33: Gutzke and Bull (1986), 34: Gutzke and Chymiy (1988), 35: Gutzke and Packard (1987), 36: Gutzke and Paukstis (1983), 37: Gutzke and Paukstis (1984), 38: Harry and Limpus (1989), 39: Hay and Magnusson (1986), 40: Hou (1985), 41: Hutton (1987), 42: Janzen (1987), 43: Janzen et al. (in press), 44: Joanen and McNease (1989), 45: Joanen et al. (1987), 46: Joss and Cuff (1987), 47: Lang (1985), 48: Lang (1987), 49: Lang et al. (1989), 50: Langerwerf (1983), 51: Langerwerf (1984), 52: Lescure et al. (1985), 53: Limpus et al. (1983), 54: Limpus et al. (1985), 55: Martinez and Cerdas (1986), 56: McCoy et al. (1983), 57: Miller and Limpus (1981), 58: Miller (1979), 59: Mirtschin (1988), 60: Mohanty-Hejmadi et al. (1985), 61: Mohanty-Hejmadi and Dimond (1986), 62: Mrosovsky (1988), 63: Mrosovsky et al. (1984), 64: Muth and Bull (1981), 65: Nakamoto and Toriba (1986), 66: Nettmann and Rykena (1985), 67: Osgood (1978), 68: Packard et al. (1989), 69: Packard et al. (1984), 70: Packard et al. (1985), 71: Pieau (1971), 72: Pieau (1972), 73: Pieau (1973), 74: Pieau (1975a), 75: Pieau (1975b), 76: Pieau (1976), 77: Pieau (1978), 78: Raynaud and Pieau (1972), 79: Rimblot et al. (1985), 80: Rimblot-Baly et al. (1987), 81: Roggenbuck and Jenssen (1986), 82: Sachsse (1984), 83: Schwarzkopf and Brooks (1985), 84: Standora and Spotila (1985), 85: Thompson (1983), 86: Thompson (1988), 87: Thorogood and Whimster (1979), 88: Tokunaga (1985), 89: Tokunaga (1986), 90: Tokunaga (1989), 91: Viets

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