REGRESSION EQUATIONS BETWEEN BODY AND HEAD MEASUREMENTS IN THE BROAD-SNOUTED CAIMAN (*Caiman latirostris*)

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ABSTRACT

In the present study, regression equations between body and head length measurements for the broad-snouted caiman (*Caiman latirostris*) are presented. Age and sex are discussed as sources of variation for allometric models. Four body-length, fourteen head-length, and ten ratio variables were taken from wild and captive animals. With the exception of body mass, log-transformation did not improve the regression equations. Besides helping to estimate body-size from head dimensions, the regression equations stressed skull shape changes during the ontogenetic process. All age-dependent variables are also size-dependent (and consequently dependent on growth rate), which is possibly related to the difficulty in predicting age of crocodilians based on single variable growth curves. Sexual dimorphism was detected in the allometric growth of cranium but not in the mandible, which may be evolutionarily related to the visual recognition of gender when individuals exhibit only the top of their heads above the surface of the water, a usual crocodilian behavior.

Key words: relative growth, sexual dimorphism, size estimates, broad-snouted caiman, *Caiman latirostris*.

RESUMO

Equações de regressão entre medidas de corpo e cabeça em jacarés-de-papo-amarelo (*Caiman latirostris*)

No presente estudo, equações de regressão entre medidas de comprimento do corpo e cabeça de jacarés-de-papo-amarelo (*Caiman latirostris*) são apresentadas. Idade e sexo são discutidos como fontes de variação para modelos alométricos. Quatro medidas de comprimento corpóreo, 14 medidas de comprimento da cabeça e dez proporções relativas entre medidas foram tomadas de animais selvagens e cativos. Com excessão da massa corpórea, a transformação logarítmica não incrementou as equações de regressão. Além de auxiliar na estimativa do comprimento corpóreo a partir de dimensões da cabeça, as equações de regressão evidenciaram alterações na forma craniana durante processos ontogênicos. Todas as variáveis dependentes da idade mostraram-se também dependentes do tamanho (e conseqüentemente da taxa de crescimento), o que está possivelmente relacionado à dificuldade em prever a idade de crocodilianos com base apenas em curvas univariadas de crescimento. Dimorfismo sexual foi detectado no crescimento alométrico do crânio, mas não da mandíbula, o que pode estar evolutivamente relacionado ao reconhecimento visual do sexo quando os indivíduos exibem apenas o topo da cabeça acima da superfície da água, um comportamento normal em crocodilianos.

Palavras-chave: crescimento relativo, dimorfismo sexual, estimativas de tamanho corpóreo, jacarés-de-papo-amarelo, *Caiman latirostris*.

INTRODUCTION

Allometric relations can be useful for estimating body size from isolated measures of parts of the body (Schmidt-Nielsen, 1984). Population monitoring of crocodilians usually involve night counts when frequently only the heads of animals are visible. Thus, the relationship between length of head and total body length is usually employed to establish size-class distribution for the target populations. As an example, Chabreck (1966) suggests that the distance between the eye and the tip of the snout in inches is similar to the total length of *Alligator mississippiensis* in feet. Choquenot & Webb (1987) propose a photographic method to estimate total length of *Crocodylus porosus* from head dimensions. In order to improve these techniques, Magnusson (1983) suggests that a sample of animals should be captured and measured. Thus, relationships between estimates and actual animals' dimensions could be established and observers' bias could be corrected. The interesting point of this method is that it permits a quantification of the actual observers' bias.

In the present study, regression equations between body and head length measurements for both wild and captive broad-snouted caiman (*Caiman latirostris*) are presented. Age and sex are discussed as sources of variation for allometric models. Sexual dimorphism, ontogenetic variation and morphometric differences between wild and captive individuals are discussed in more detail by Verdade (1997).

MATERIAL AND METHODS

Body and head measurements were taken from 244 captive and 29 wild animals. The captive animals were located at *Escola Superior de Agricultura "Luiz de Queiroz"*, University of São Paulo, Piracicaba, State of São Paulo, Brazil. Information about their age, sex, date of birth, and pedigree are available at the regional studbook of the species (Verdade & Santiago, 1991; Verdade & Molina, 1993; Verdade & Kassouf-Perina, 1993; Verdade & Sarkis, in press). The wild animals were captured on small wetlands associated with tributaries of Tietê River in East-Central São Paulo State from October 1995 to May 1996.

Capture techniques consisted of approaching the animals by boat at night with a spotlight. Juveniles (< 1.0 m total length) were captured by hand, similar to the method described by Walsh (1987). Noosing, as described by Chabreck (1963), was tried unsuccessfully for adults. The adult caimans were too wary and usually submerged before the noose was in place, similarly to what was experienced by Webb & Messel (1977) with *Crocodylus porosus* in Australia and Hutton *et al*. (1987) in Zimbabwe. Rope traps (adapted from Walsh, 1987) were also tried unsuccessfully for both adults and young. Captive individuals were taken either by hand or noose according to their size, on daytime in October 1996.

The captured animals were physically restrained during data collection. No chemical immobilizion was used. Body measurements (body-size variables) were taken with a tape measure (1 mm precision). Head measurements (head-size variables) were taken with a steel Summit Vernier caliper (.02 mm precision, second decimal unconsidered). Body mass was taken with Pesola hanging scales (300 x 1 g, 1,000 x 2 g, 5,000 x 5 g, 20 x 0.1 kg, 50 x 0.1 Kg, depending on individual body mass). Animals were sexed through manual probing of the cloaca (Chabreck, 1963) and/or visual examination of genital morphology (Allstead & Lang 1995) with a speculum of appropriate size.

Four body-size, fourteen head-size, and ten ratio variables were taken from wild and captive animals (Fig. 1, Table 1). Eight head-size variables are "length" measurements in the sense that they are longitudinal in relation to the body. The other six head-size variables are "width" measurements in the sense that they are transversal in relation to the body. Ten head-size variables are located on the upper jaw and cranium, whereas the other four head-size variables are located on the lower jaw. Four ratio variables represent relative length, whereas the other six represent relative width. Eight ratio variables are located on the upper jaw and cranium, whereas the other two are located on the lower jaw. One of these measurements, PXS, the length of the premaxillary symphysis, is not visible in live animals but is closely approximated by the distance from the snout tip to the anterior tip of the first tooth posterior to the prominent groove in the snout behind the nares (usually the 6th or 7th tooth).

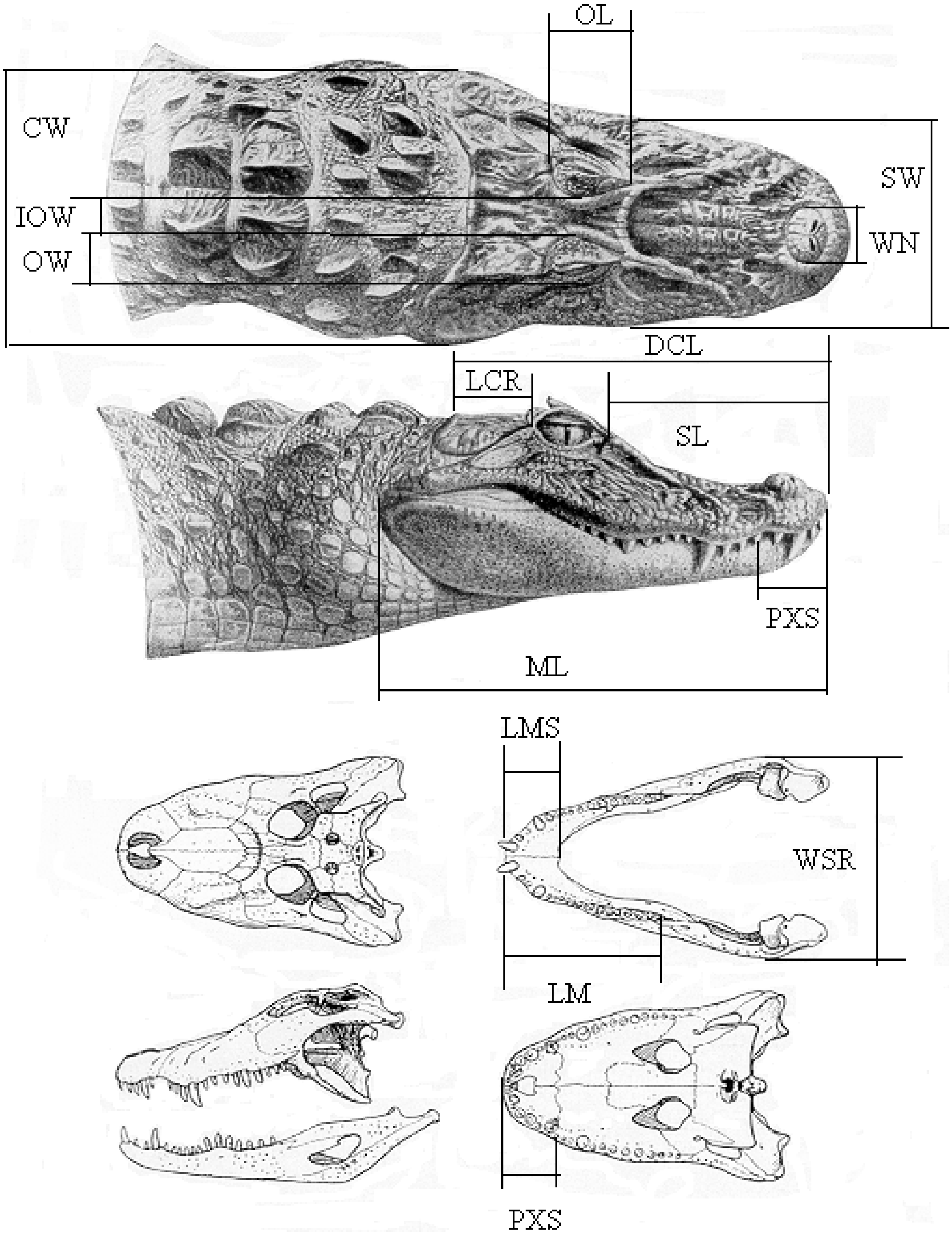

Fig. 1 — Head measurements adapted from Iordansky (1973). Dorsal and lateral view of *Caiman latirostris* head. See Table 1 for description of variables. Ilustration adapted from Wermuth & Mertens (1961:351, Fig. 250, after Natterer 1840. *Ann. nat.-hist*. Wien 2: Tab. XXII).

TABLE 1

Measurements (adapted from Iordansky, 1973).

Abbreviation	Type	Explanation	Unit
SVL	Body-size	Snout-vent length	cm
TTL	Body-size	Total length: anterior tip of snout to posterior tip of tail	cm
BW	Body-size	Commercial belly width: the width across the ventral belly and lateral flank scales between the distal margins of the third transverse row of dorsal scutes	mm
BM	Body-size	Body mass	Kg
DCL	Head-size	Dorsal cranial length: anterior tip of snout to posterior surface of occiptal condyle	mm
CW	Head-size	Cranial width: distance between the lateral surfaces of the mandibular condyles of the quadrates	mm
SL	Head-size	Snout length: anterior tip of snout to anterior orbital border, measured diagonally	mm
SW	Head-size	Basal snout width: width across anterior orbital borders	mm
OL	Head-size	Maximal orbital length	mm
OW	Head-size	Maximal orbital width	mm
IOW	Head-size	Minimal interorbital width	mm
LCR	Head-size	Length of the postorbital cranial roof: distance from the posterior orbital border to the posterolateral margin of the squamosal	mm
WN	Head-size	Maximal width of external nares	mm
PXS	Head-size	Length of palatal premaxilary symphysis (approximated for live animals by the distance from the anterior tip of snout to anterior tip of the first tooth posterior to the prominent grove in the snout behind the nares (usually the 6th or 7th tooth)	mm
ML	Head-size	Mandible length: anterior tip of dentary to the posterior tip of the retroarticular process	mm
LMS	Head-size	Length of the mandibular symphysis	mm
WSR	Head-size	Surangular width: posterolateral width across surangulars at point of jaw articulation	mm
LM	Head-size	Length of lower ramus: anterior tip of dentary to posterior margin of distal most dentary alveolus	mm
RCW	Ratio	Relative cranial width: CW/DCL	
RLST	Ratio	Relative length of snout: SL/DCL	
RWST	Ratio	Relative width of snout: SW/SL	
ROL	Ratio	Relative orbital length: OL/DCL	
ROW	Ratio	Relative orbital width: OW/OL	
RWI	Ratio	Relative interorbital width: IOW/OL	
RWN	Ratio	Relative width of external nares: WN/(DCL-SL)	
RPXS	Ratio	Relative length of premaxillary symphysis: PXS/DCL	
RLSS	Ratio	Relative length of mandibular symphysis: LMS/ML	
RWM	Ratio	Relative width of mandible: WSR/ML	

"Size" and "shape" are difficult to define in biology (Bookstein, 1989). Unidimensional length measurements do not express the multidimensionality of size. However, since length and size are positively correlated in caimans, length measurements are called size-variables in this paper for the sake of simplicity. The morphometric variables used in this study were adapted from Iordansky

(1973). They are based on linear distances between landmarks (body- and head-size variables) or ratios between measurements (ratio variables). The use of ratios present several disadvantages. Ratios tend to be relatively inaccurate, not-normally distributed, and discontinuous (Sokal & Rohlf, 1995). However, since ratios are still used by some authors (Hall & Portier, 1994) they have been included and discussed in the present study for comparative purposes.

Hall and Portier call these ratios *relative growth indices*. Relative growth represents change of proportions as body size increases. The study of relative growth has been characterized by Gould (1966) as the study of size and its implications in ontogeny and phylogeny. However, disregarding growth processes and size implications, these ratios express non-metric variables in the sense that they represent relative length and width instead of absolute values.

All statistical analyses were done in Minitab for Windows (Minitab, 1996) and their procedures are shown when adequate.

ALLOMETRIC RELATIONS

Table 2 and Fig. 2 show the regression equations and respective plots between body- and head-size variables and the snout-vent length (SVL) in wild individuals. Table 3 and Fig. 3 show the regression equations and respective plots between ratio variables and SVL in wild individuals. Due to the relatively small sample size, wild males and females are presented together. Table 4 and Fig. 4 show the regression equations and respective plots between body- and head-size variables and the snout-vent length (SVL) in captive animals. Table 5 and Fig. 5 show the regression equations and respective plots between ratio variables and SVL in captive animals.

TABLE 2

Regression equations between body- and head-size variables for wild individuals.

#	Sex	Y	X	a	b	c	P-value	r^2	N
1	m/f	TTL	SVL	3.5645	1.8625		0.000	0.971	29
2	m/f	SVL	Log BM	363.4319	23.7548		0.000	0.972	29
3	m/f	SVL	BW	9.5225	0.1996		0.000	0.828	29
4	m/f	SVL	DCL	–3.7857	0.4816		0.000	0.968	29
5	m/f	SVL	CW	0.1500	0.6596		0.000	0.979	29
6	m/f	SVL	SL	21.6031	–0.3281	0.0174	0.000	0.960	29
7	m/f	SVL	SW	15.3405	–0.0067	0.0109	0.000	0.977	29
8	m/f	SVL	OL	–11.8575	2.1830		0.000	0.826	29
9	m/f	SVL	OW	46.1599	–5.9175	0.3686	0.000	0.841	29
10	m/f	SVL	IOW	4.5033	4.4825		0.000	0.879	29
11	m/f	SVL	LCR	–10.9432	2.0376		0.000	0.883	29
12	m/f	SVL	WN	–2.1679	3.7140		0.000	0.893	29
13	m/f	SVL	PXS	2.1387	2.0340		0.000	0.892	29
14	m/f	SVL	ML	–0.2700	0.3652		0.000	0.969	29
15	m/f	SVL	LMS	1.5657	2.5035		0.000	0.908	29
16	m/f	SVL	WSR	–0.4400	0.7189		0.000	0.960	29

$Y = a + bX + cX^2 + dX^3$.

Sex: m/f = males and females.

N: Sample size.

Minitab procedure: Stat → Regression → Fitted Line Plot (Polynomial Regression).

With the exception of BM, variables were not transformed because their orders of magnitude are similar and transformation did not improve results.

Quadratic element (c) was included in the equation ($c \neq 0$) whenever significant ($P\text{-value} \leq 0.05$).

TABLE 3

Regression equations between body-length (SVL) and head ratio variables for wild individuals.

#	Sex	Y	X	a	b	c	d	P-value	r²	N
1	m/f	SVL	RCW	–66.8226	150.884			0.000	0.370	29
2	m/f	SVL	RLST	7806.83	–52284.4	116487.0	–86021.1	0.000	0.581	29
3	m/f	SVL	RWST	79.0565	–43.1568			0.045	0.140	29
4	m/f	SVL	ROL	96.0670	–238.949			0.000	0.523	29
5	m/f	SVL	ROW	14.5130	24.6588			0.323	0.036	29
6	m/f	SVL	RWI	–0.2700	103.195			0.000	0.437	29
7	m/f	SVL	RWN	–2.5876	144.094			0.029	0.164	29
8	m/f	SVL	RPXS	–6.9892	190.882			0.050	0.135	29
9	m/f	SVL	RLSS	24.8324	38.6619			0.805	0.002	29
10	m/f	SVL	RWM	41.2090	–21.6420			0.687	0.006	29

$Y = a + bX + cX^2 + dX^3$.

Sex: m/f = males and females.

N: Sample size.

Minitab procedure: Stat → Regression → Fitted Line Plot (Polynomial Regression).

With the exception of BM, variables were not transformed because their orders of magnitude are similar and transformation did not improve results.

Cubic element (d) was included in the equation ($d \neq 0$) whenever significant (P-value ≤ 0.05).

Quadratic element (c) was included in the equation ($c \neq 0$) whenever either quadratic or cubic element were significant (P-value ≤ 0.05).

With the exception of body mass (BM), log-transformation did not improve regression equations for either wild or captive animals. Logarithmic transformation is a simple device that may ease and improve diagrammatic and statistical descriptions of the effect of body size on other attributes (Peters, 1983). Regression equations for captive animals presented a higher coefficient of determination (r^2) than the ones for wild animals. Body- and head-size variables presented a significantly higher r^2 than ratio variables for both wild and captive animals. They varied from 0.826 (OL) to 0.979 (CW) for body- and head-size variables (Table 2), and from 0.002 (RLSS) to 0.581 (RLST) for ratio variables (Table 3) for wild animals. For captive animals, in their turn, they varied from 0.916 (OW) to 0.993 (SW) for body- and head-size variables (Table 4), and from 0.003 (RLSS) to 0.934 (RLST) for ratio variables. The range of SVL relative to each equation can be found on the plots of Figs. 2 to 5.

The coefficients of determination of wild and captive animals concerning body- and head-size variables can be considered extremely high. Their main biological meaning is the apparent lack of morphological variation on the patterns studied, which could be expected for captive but not for wild animals. They also mean that most of the head-size variables studied can be useful for predicting body length. This can be particularly interesting for the study of museum collections, or even poaching wastes, in which only crania are usually preserved or found relatively intact. However, the present study lacks adult wild individuals.

Some precaution is advised when using ratio variables for predicting body length. Some of these regression equations are not statistically significant (P-value > 0.100). This is the case for the following variables: ROW, RLSS, and RWM for wild, and ROW and RLSS for captive animals). Plots in Figs. 3 and 3 help to visualize these patterns.

Besides helping to estimate body-size from head dimensions, the regression equations of the present study stress skull shape changes during the ontogenetic process. Non-linear equations express changes on the proportions of the skull, “accelerated” or “decelerated” on the inflexion points. For instance, the cranium of captive animals becomes relatively narrower as body size increases (see plot of CW in Fig. 4).

TABLE 4

Regression equations between body- and head-size variables for captive animals.

#	Sex	Y	X	a	b	c	d	P-value	r^2	N
1	m/f	TTL	SVL	–1.0676	2.1137	–0.0023		0.000	0.991	120
2	m/f	SVL	LogBM	33.9700	25.1064	8.5085		0.000	0.985	120
3	m	SVL	BW	–1.2766	0.2686	–0.0001		0.000	0.990	25
4	f	SVL	BW	3.4563	0.2878	–0.0004	0.0000004	0.000	0.981	95
5	m/f	SVL	DCL	–6.3508	0.5233			0.000	0.995	120
6	m/f	SVL	CW	–4.5445	0.7817	–0.0010		0.000	0.992	120
7	m/f	SVL	SL	1.4248	0.9152	–0.0009		0.000	0.991	120
8	m/f	SVL	SW	–1.7795	0.8650	–0.0006		0.000	0.993	120
9	m	SVL	OL	52.9583	–6.5744	0.3427	–0.0037	0.000	0.982	25
10	f	SVL	OL	33.1170	–3.9947	0.2478	–0.0028	0.000	0.978	95
11	m	SVL	OW	–31.7964	4.8182			0.000	0.916	25
12	f	SVL	OW	13.1192	–3.3430	0.5300	–0.0110	0.000	0.939	95
13	m/f	SVL	IOW	7.5263	4.1475			0.000	0.954	120
14	m/f	SVL	LCR	–17.0139	2.4719			0.000	0.981	120
15	m/f	SVL	WN	–3.3524	3.4338			0.000	0.974	120
16	m/f	SVL	PXS	–6.9334	2.8570	–0.0132		0.000	0.932	120
17	m/f	SVL	ML	–1.0735	0.3818			0.000	0.986	120
18	m/f	SVL	LMS	–3.4050	2.9359	–0.0098		0.000	0.975	120
19	m/f	SVL	WSR	–3.6564	0.8224	0.0011		0.000	0.990	120
20	m/f	SVL	LM	7.2401	0.0567	0.0203	–0.0002	0.000	0.989	98

$Y = a + bX + cX^2 + dX^3$.

Sex: m = males; f = females; m/f = males and females.

N: Sample size.

Minitab procedure: Stat → Regression → Fitted Line Plot (Polynomial Regression).

With the exception of BM, variables were not transformed because their orders of magnitude are similar and transformation did not improve results.

Cubic element (d) was included in the equation ($d \neq 0$) whenever significant ($P\text{-value} \leq 0.05$).

Quadratic element (c) was included in the equation ($c \neq 0$) whenever either quadratic or cubic element were significant ($P\text{-value} \leq 0.05$).

Males and females presented separately when ANCOVA for sex was significant ($P\text{-value} \leq 0.05$). See Table 6 for P-values.

A similar and expected pattern can be seen on the mandible (see plot of WSR in the same figure). In both cases, regression equations are quadratic with the coefficient of the quadratic element being negative (see Table 4).

A somewhat sigmoid shape can be perceived on the relative growth curve of the eye-orbit length (OL) and width (OW) in captive animals. A positive quadratic and a negative cubic element in the allometric equations of both cases show a period of fast relative growth in young followed by a period of slow relative growth of these regions in adult animals. The smaller coefficient of the linear element of the OW equation than of the OL equation express the ontogenetic process of "elongation" suffered by the eye-orbits during initial development of the animals.

Age and Sex as Covariates of Body Size

Table 6 shows the analysis of covariance (ANCOVA) of sex and age of captive animals in relation to the regression equations between morphometric variables and snout-vent length (SVL).

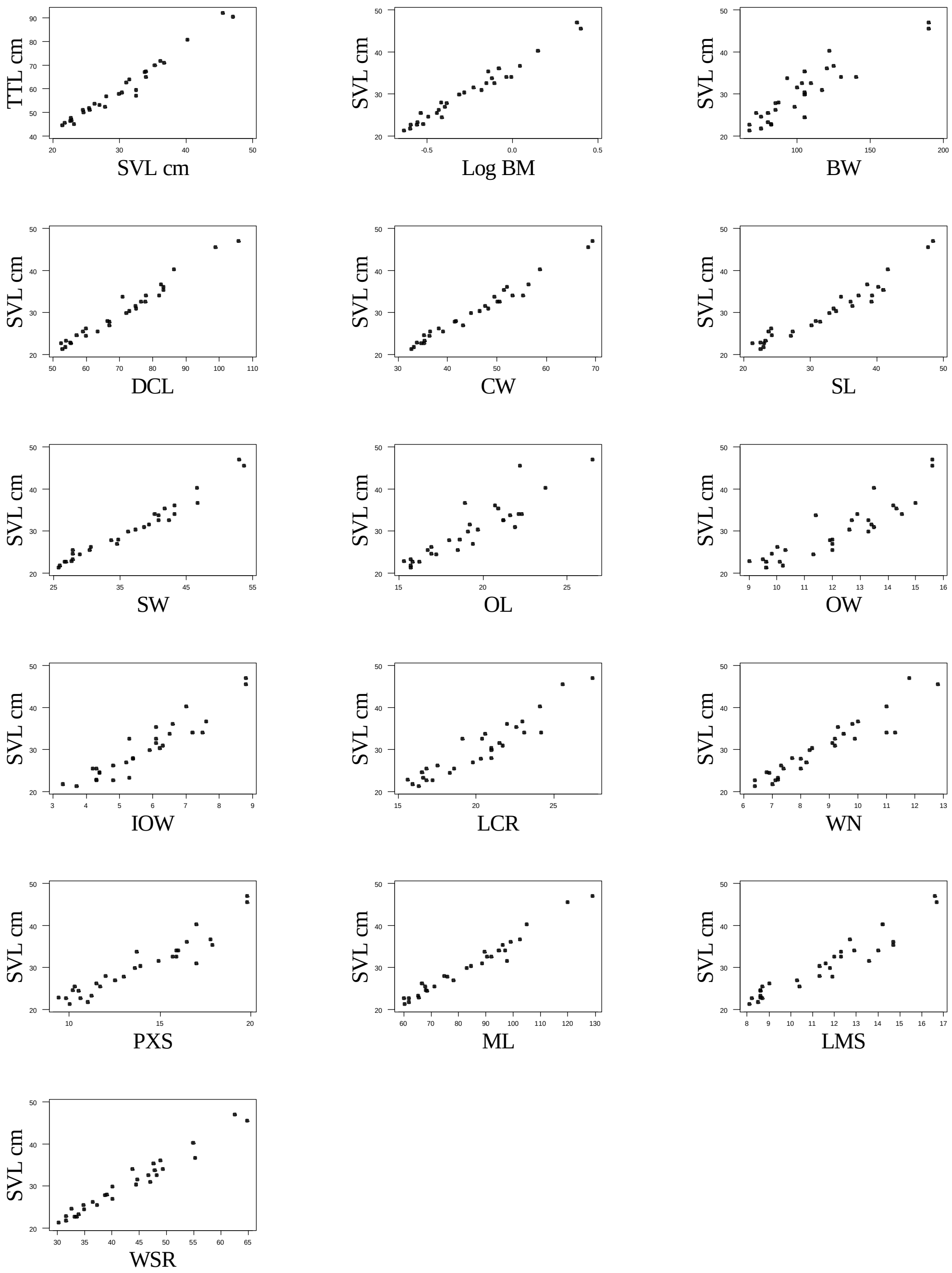

Fig. 2 — Plots between body- and head-size variables for wild individuals (Log BM: log-transformed BM; SVL and TTL in *cm*, the others in *mm*). See Table 2 for regression equations.

TABLE 5

Regression equations between body-length (SVL) and head-ratio variables.

#	Sex	Y	X	a	b	c	d	P-value	r^2	N
1	m	SVL	RCW	–214.951	367.644			0.000	0.901	25
2	f	SVL	RCW	8813.67	–36715.4	50550.9	–22872	0.000	0.839	95
3	m	SVL	RLST	219.636	–1106.28	1501.35		0.000	0.934	25
4	f	SVL	RLST	1706.86	–10271.9	20270	–12759	0.000	0.871	95
5	m/f	SVL	RWST	–4630.87	13093	–11943.9	3557.43	0.000	0.452	120
6	m	SVL	ROL	541.144	–3188.86	4835.37		0.000	0.925	25
7	f	SVL	ROL	–569.433	9513.45	–43137.6	60117.3	0.000	0.859	95
8	m	SVL	ROW	126.165	–123.61			0.034	0.180	25
9	f	SVL	ROW	26.2212	24.0213			0.534	0.040	95
10	m/f	SVL	RWI	104.269	–889.836	2910.8	–2443.13	0.000	0.808	120
11	m	SVL	RWN	–109.85	549.146			0.000	0.674	25
12	f	SVL	RWN	575.858	–5780.9	19176.8	19294	0.000	0.810	95
13	m/f	SVL	RPXS	239.553	–2197.54	5885.48		0.000	0.118	120
14	m/f	SVL	RLSS	24.3543	108.483			0.565	0.003	120
15	m/f	SVL	RWM	404.504	–1595.72	1691.74		0.000	0.264	120
16	m/f	SVL	RLLMR	56.6448	–54.4797			0.068	0.835	98

$Y = a + bX + cX^2 + dX^3$.

Sex: m = males; f = females; m/f = males and females.

N: Sample size.

Minitab procedure: Stat → Regression → Fitted Line Plot (Polynomial Regression).

With the exception of BM, variables were not log-transformed because their orders of magnitude are similar and log-transformation did not improve results.

Cubic element (d) was included in the equation ($d \neq 0$) whenever significant (P-value ≤ 0.05).

Quadratic element (c) was included in the equation ($c \neq 0$) whenever either quadratic or cubic element were significant (P-value ≤ 0.05).

Males and females presented separately when ANCOVA for sex was significant (P-value ≤ 0.05). See Table 6 for P-values.

ANCOVA may be used to compare males and females' equations. It may also be useful to separate age from body-size effect on the regressions analyzed.

All body- and head-size variables, and all but three ratio variables (RWI, RWN, and RPXS) are significantly affected by body size (P-value > 0.100), or in other words, they can be considered size-dependent. One body-size (BW), six head-size (CW, SL, OL, OW, PXS, and WSR), and one ratio variable (ROL) are significantly affected by age (P-value > 0.100), i.e., they can be considered age-dependent.

At last one body-size (BW), two head-size (OL and OW), and five ratio variables (RCW, RLST, ROL, ROW, and RWN) are significantly affected by gender (P-value > 0.100).

Webb & Messel (1978) report a perceptible sexual dimorphism in *Crocodylus porosus* involving interorbital width, which is not perceived in the present study. Hall & Portier (1994) found sexual dimorphism for 21 of 34 skull attributes, including DCL, ML, PXS, CW, OW, IOW, WCR, WN, and WSR. However, their results are possibly optmistic because they could not include age as a covariate of body size in their study of allometric growth of *Crocodylus novaeguineae*. Some variation actually caused by age (independent of size) may be erroneously accounted as a difference between sexes, or sexual dimorphism.

The fact that all age-dependent variables are also size-dependent explains why it is so difficult to predict age of crocodilians based on single variable growth curves (see Verdade, 1997, for discussion).

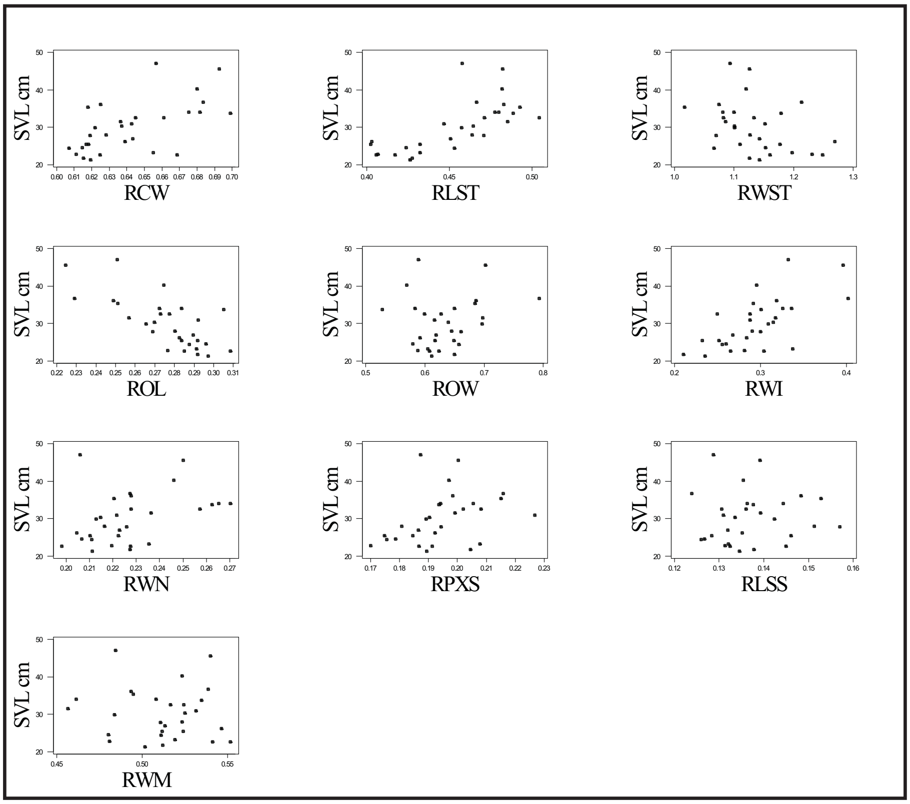

Fig. 3 — Plots between body-size and ratio variables for wild individuals. See Table 3 for regression equations.

TABLE 6

Analysis of covariance: Age and sex as covariates of SVL (P-values).

Variable	SVL	Age	Sex	Variable	SVL	Age	Sex
BM	0.000	0.812	0.308	RCW	0.003	0.392	0.026
BW	0.000	0.061	0.010	RLST	0.000	0.474	0.018
DCL	0.000	0.233	0.283	RWST	0.088	0.805	0.312
CW	0.000	0.012	0.192	ROL	0.002	0.033	0.007
SL	0.000	0.057	0.167	ROW	0.007	0.203	0.000
SW	0.000	0.480	0.989	RWI	0.292	0.509	0.376
OL	0.000	0.004	0.001	RWN	0.298	0.946	0.060
OW	0.000	0.032	0.004	RPXS	0.632	0.574	0.227
IOW	0.002	0.123	0.548	RLSS	0.058	0.327	0.746
LCR	0.000	0.308	0.347	RWM	0.002	0.367	0.582
WN	0.000	0.841	0.459	RLLMR	0.001	0.667	0.779
PXS	0.005	0.075	0.396				
ML	0.000	0.128	0.173				
LMS	0.000	0.521	0.830				
WSR	0.000	0.020	0.448				
LM	0.000	0.972	0.972				

Minitab procedure: Stat → ANOVA → General Linear Model.
Response (dependent variables): morphometric variables.
Model (independent variable): *SVL*.
Covariates: *Age* and *Sex*.

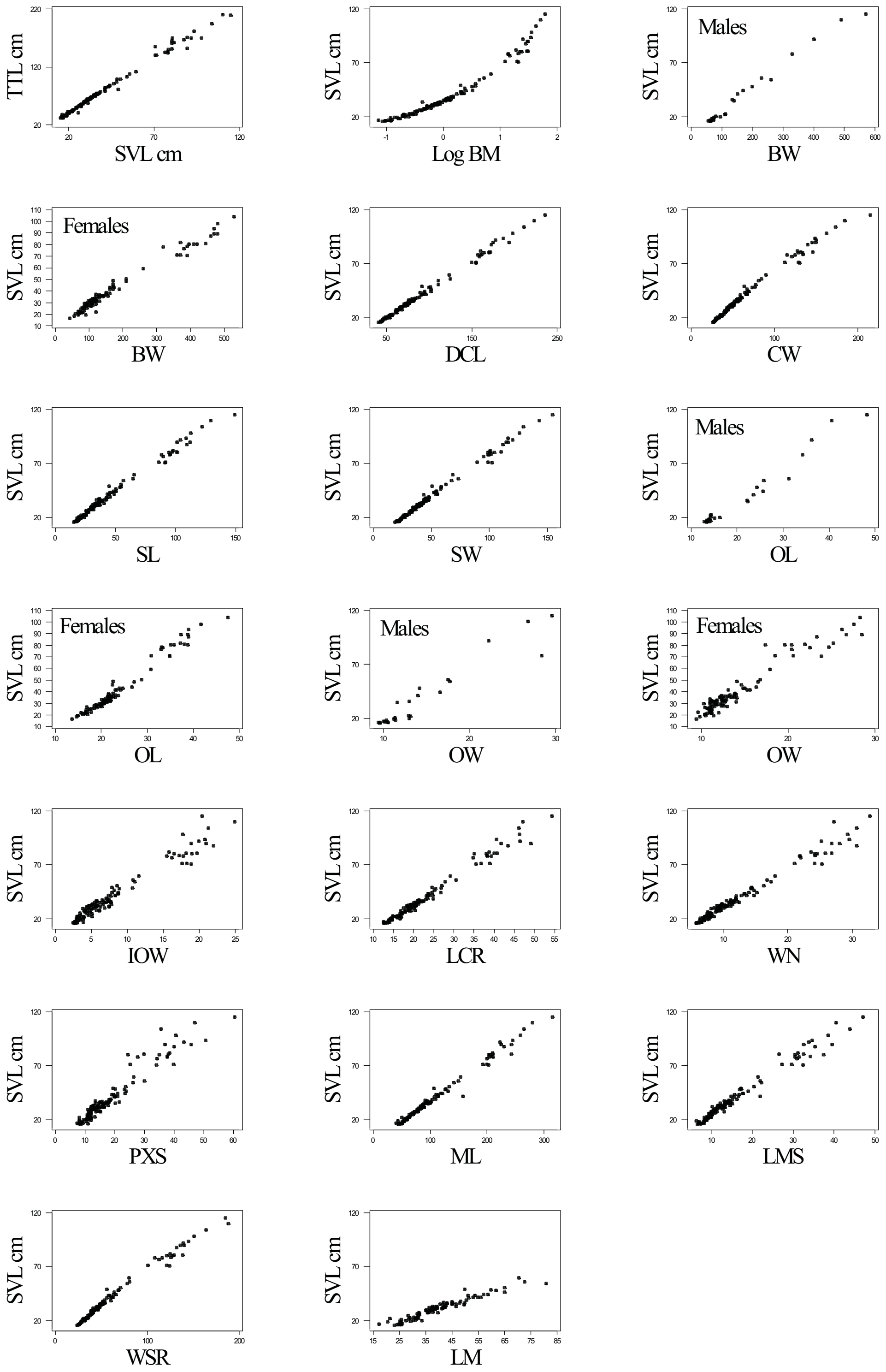

Fig. 4 — Plots between body- and head-size variables for captive individuals. Males and females presented together unless stated otherwise. See Table 4 for regression equations. See Table 6 for ANCOVA P-values.

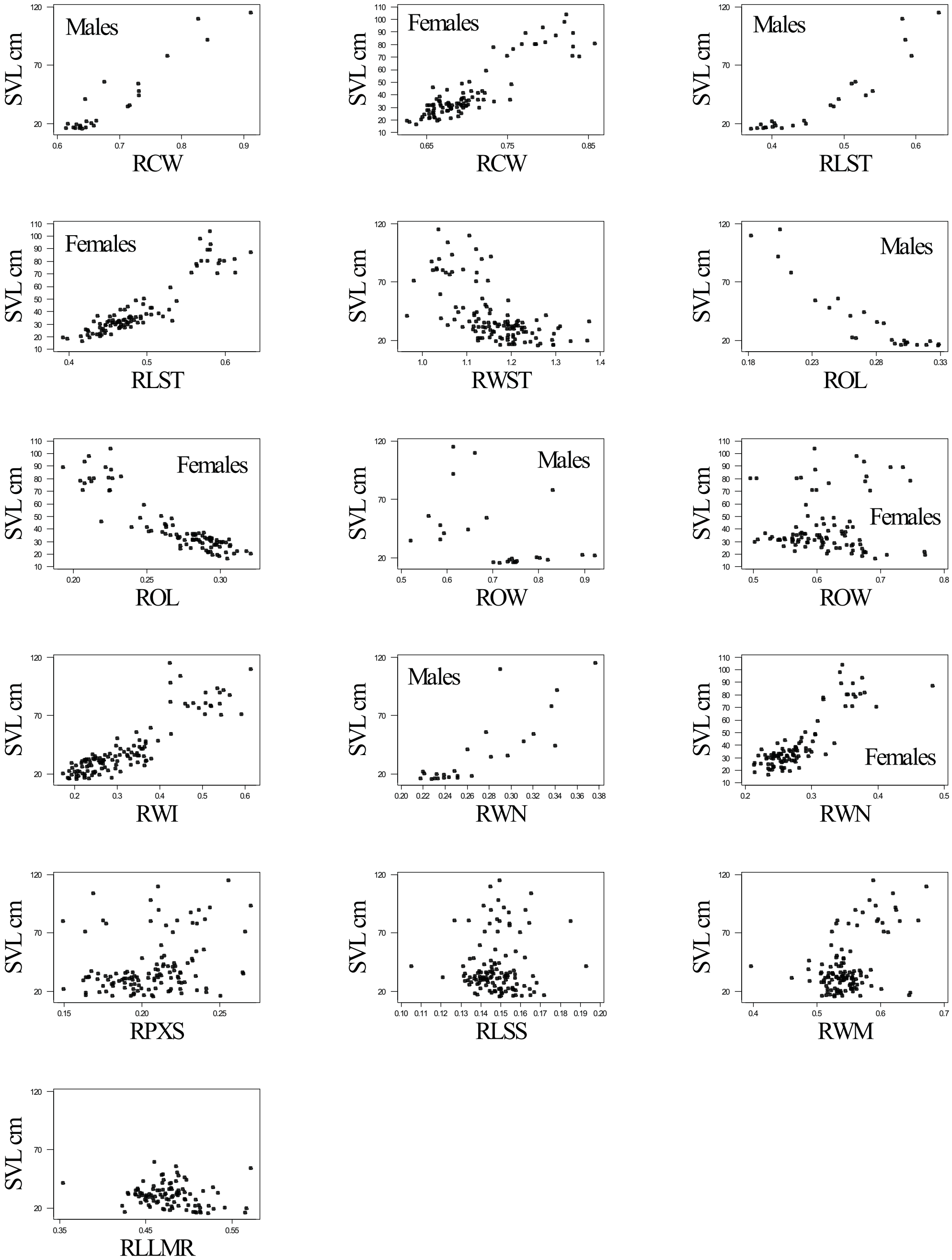

Fig. 5 — Plots between body-size and ratio variables for captive individuals. Males and females presented together unless stated otherwise. See Table 5 for regression equations. See Table 6 for ANCOVA P-values.

All of the sex-dependent variables are also size dependent, with the exception of RWN. However, its efficiency in predicting individual sex through discriminant analysis is low. Four sex-dependent variables (BW, OL, OW, and ROL) are also age-dependent, but the remaining four, all of them ratio variables (RCW, RLST, ROW, and RWN), are not. Age-dependent as well as sex-dependent variables are primarily located on the cranium. Only one age-dependent (WSR) and sex-independent variable is located on the mandible.

Sexual dimorphism was detected in the allometric growth of BW, OL, OW, RCW, RLST, ROL, ROW, and RWN. With the exception of BW, all of these morphometric variables are located in the cranium and none in the mandible. This may be evolutionarily related to the visual recognition of gender when individuals exhibit only the top of their heads above the surface of the water, a usual behavior of crocodilians. A multivariate approach for the study of sexual dimorphism is discussed by Verdade (1997).

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