Chapter 3

Morphometric Comparisons of the Skull and Carapace of Chitra chitra Nutphand, 1986 and Chitra indica (Gray, 1831) (Testudines: Trionychidae)

Abstract

Skull and carapace measurements were compared between Chitra indica of the Indian Subcontinent and Chitra chitra of Thailand using discriminant analysis. Based upon 27 skull ratio characters from 6 skulls of C. indica and 9 skulls of C. chitra and 53 carapace ratio characters from 6 carapaces of C. indica and 10 carapaces of C. chitra compared, these analyses indicate that there are clear osteological differences between Indian and Thai forms. The magnitude of the variation displayed by these analyses supports the argument that Thai animals warrant specific status.

Key words: Chitra chitra, Chitra indica, Morphometric Comparison, Discriminant Analysis, Skull, Carapace

Introduction

The Siamese Narrow-headed softshell turtle of the Mae Klong river system of Western Thailand, probably the largest softshell in the world (Pritchard, 2001), was long recognized as only a disjunct population of the Indian subcontinent species, Chitra indica (Nutphand, 1979; Smith, 1931; and Taylor, 1970). More recently, Nutphand (1986) in a magazine article described the population inhabiting Thailand as a new species, Chitra chitra, based solely on its color, stripe pattern and larger adult size – all characters which he believed separated it from C. indica of the Indian subcontinent. Thirakhupt and van Dijk (1994) and van Dijk and Thirakhupt (1995) lent support to this designation by referring to this animal as C. chitra in their accounts of its status and conservation requirements in their reviews of the diversity and conservation of the turtles of western Thailand. C. chitra has since been designated as a Critically Endangered Species (CR) by IUCN (1996), but its specifics status remains controversial. To further clarify the level of differentiation between Indian and Thai Chitra, an array of osteological characteristics of the skull and carapace of both taxa were examined and analysed. The results of these comparisons and their significance are provided below.

Materials and Methods

Specimens of C. chitra and C. indica were examined at BNHM (The Natural History Museum, London), MCZ (Museum of Comparative Zoology, Harvard University), FMNH (The Field Museum, Chicago) and CUB MZ (Chulalongkorn University Bangkok, Museum of Zoology) (table 3.1).

Table 3.1 Specimen types, localities, catalog numbers, museums and collectors of Chitra specimens in this study.

No.	Specimen type	Localities	Catalog Number	Museum	Collectors
1	carapace	Thailand	1974.2451	NHM	M. A. Smith
2	skull, carapace	Thailand	1962.12.16.1	NHM	M. A. Smith
3	skull, carapace	India	86.2.1.1	NHM	-
4	skull	India	-	NHM	Falconer
5	skull, carapace	India	87.3.30.11	NHM	W. Theobald
6	skull, carapace	India	1984.1276	NHM	Rothshild
7	skull, carapace	Thailand	29486	MCZ	M. A. Smith
8	skull	Thailand	29487	MCZ	M. A. Smith
9	carapace	Thailand	29488	MCZ	M. A. Smith
10	skull, carapace	India	-	MCZ	-
11	carapace	India	224234	FMNH	E. O. Moll
12	skull, carapace	India	224228	FMNH	E. O. Moll
13	carapace	Thailand	1994 - 4 -21,1	CUBMZ	Thirakhupt
14	skull, carapace	Thailand	CUBMZ R 2001.10	CUBMZ	Thirakhupt & Kitimasak
15	skull, carapace	Thailand	CUBMZ R 2001.11	CUBMZ	Thirakhupt & Kitimasak

Table 3.1 (continued). Specimen types, localities, catalog numbers, museums and collectors of Chitra specimens in this study.

No.	Specimen type	Localities	Catalog Number	Museum	Collectors
16	skull, carapace	Thailand	CUBMZ R 2001.12	CUBMZ	Thirakhupt & Kitimasak
17	skull, carapace	Thailand	CUBMZ R 2001.13	CUBMZ	Thirakhupt
18	skull	Thailand	CUBMZ R 2001.14	CUBMZ	Thirakhupt & Kitimasak
19	skull, carapace	Thailand	CUBMZ R 2001.15	CUBMZ	Thirakhupt & Kitimasak
20	carapace	Thailand	CUBMZ R 2001.16	CUBMZ	Thirakhupt

Six skulls and 6 carapaces of 7 adult C. indica and 9 skulls and 10 carapaces of 13 adult C. chitra were examined. Twenty-seven characters of each skull (Figure 3.1) and 53 characters of each carapace (Figure 3.2) were measured for this study. These characters and their abbreviations are listed in the appendix.

Skull and carapace variables were divided by SW (Skull Width) and BDL (Bony Disc Length), respectively in order to decrease error due to size variation. Best discriminating variables were selected with a forward stepwise discriminant analysis, using the highest F Value as entrance criteria. The discriminant function was established employing the polled covariance matrix and proportional prior probabilities of membership, since sample sizes were unequal. Statistical analyses were carried out using SPSS program (Ver. 10).

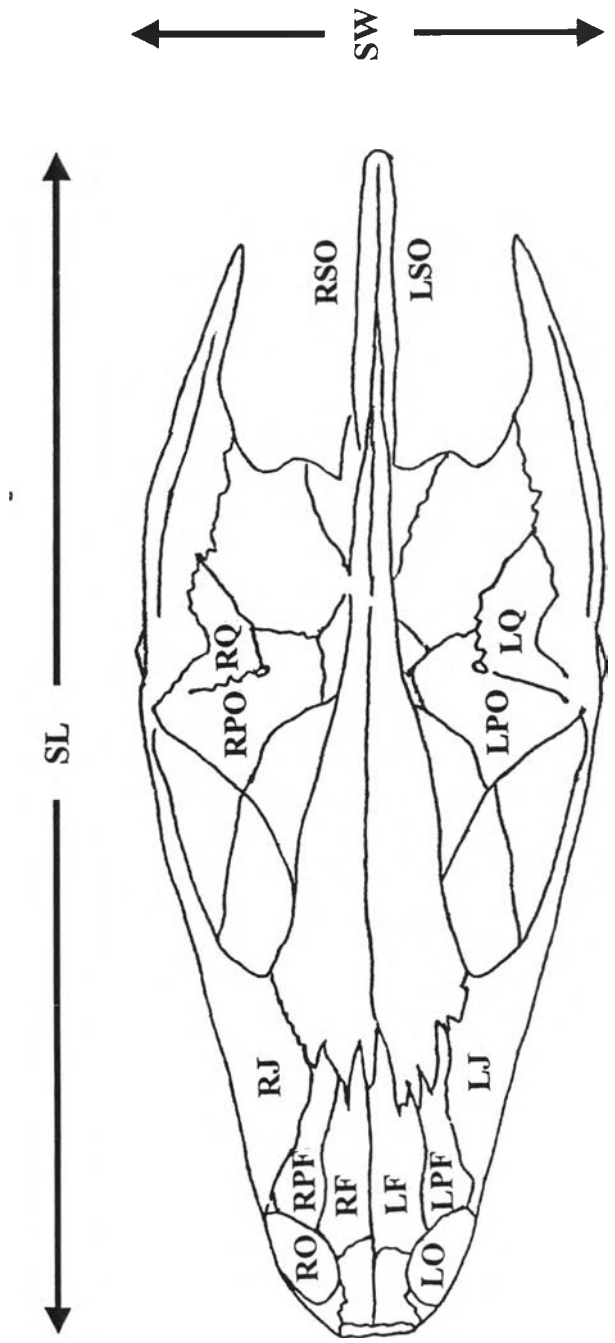

Figure 3.1 Skull variables of C. chitra and C. indica

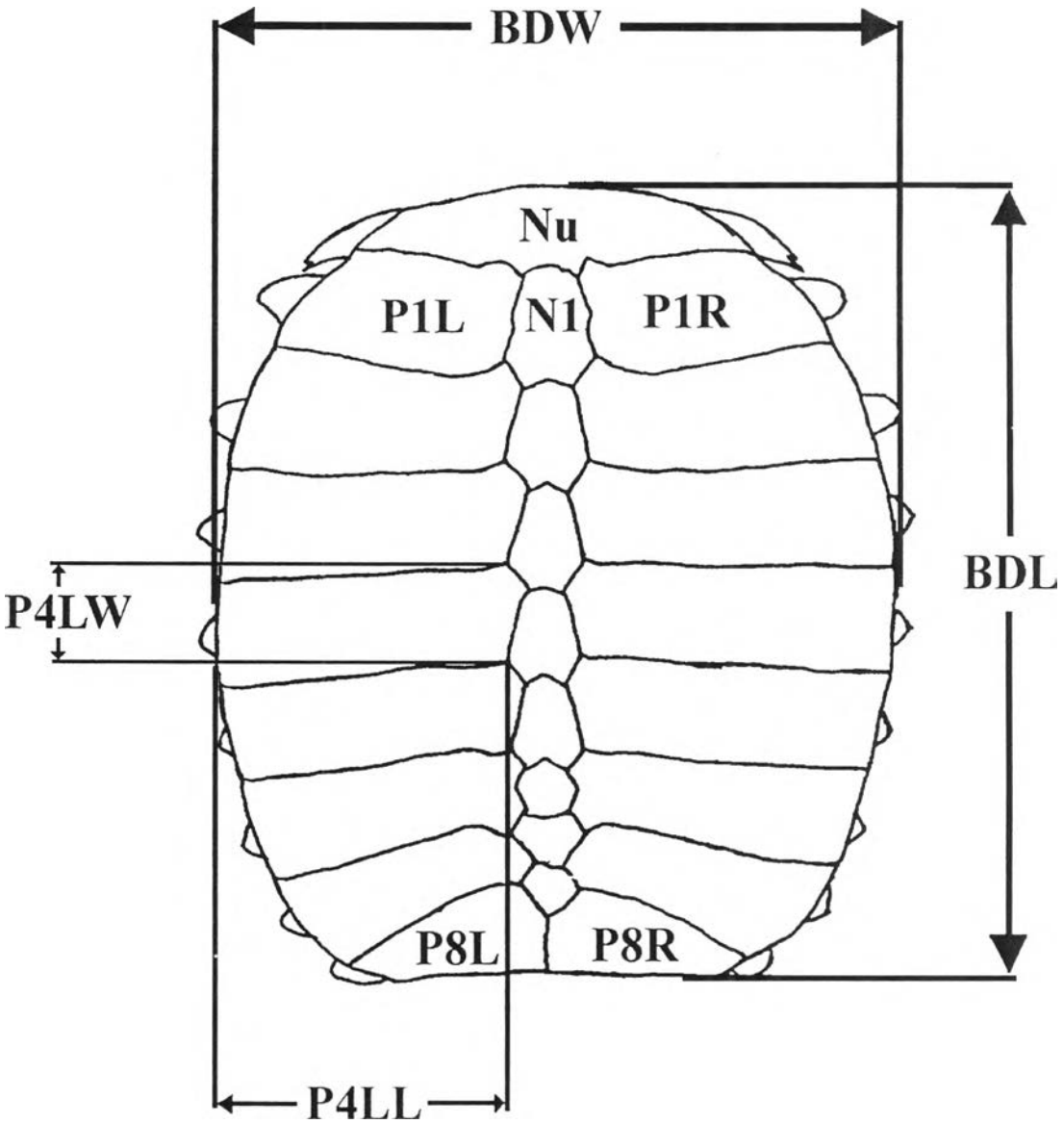

Figure 3.2 Carapace variables of C. chitra and C. indica

Results

Skull Analysis

Seven from 26 skull ratio characters were chosen in this study. In the stepwise discriminant procedure the ratio of RPFL/SW, RPFW/SW, LPOL/SW, NW/SW, SH/SW, RPOW/SW and LPFW/SW were the best discriminating variables, achieving 100% original grouped cases correctly classified (Table 3.2).

Table 3.2 Statistics of the skull variables selected by forward stepwise discriminant analysis for species discrimination between C. chitra and C. indica. The variables were listed in order of entrance in the model.

Variable	step	Wilks' Lambda	Exact F	P
RPFL/SW	1	0.570	7.531	0.021
RPFW/SW	2	0.278	11.706	0.003
LPOL/SW	3	0.109	21.763	<0.001
NW/SW	4	0.059	28.151	<0.001
SH/SW	5	0.029	39.865	<0.001
RPOW/SW	6	0.012	69.687	<0.001
LPFW/SW	7	0.005	107.880	<0.001

The discriminant scores of skulls vary from +10 to +12.5 in C. chitra and -13.5 to -16 in C. indica. There was a non-overlapping distribution of discriminant scores of skulls between C. chitra and C. indica (Figure 3.3). As a result, the discriminant scores of skulls in Figure 3.3 have distinguished C. chitra from C. indica effectively.

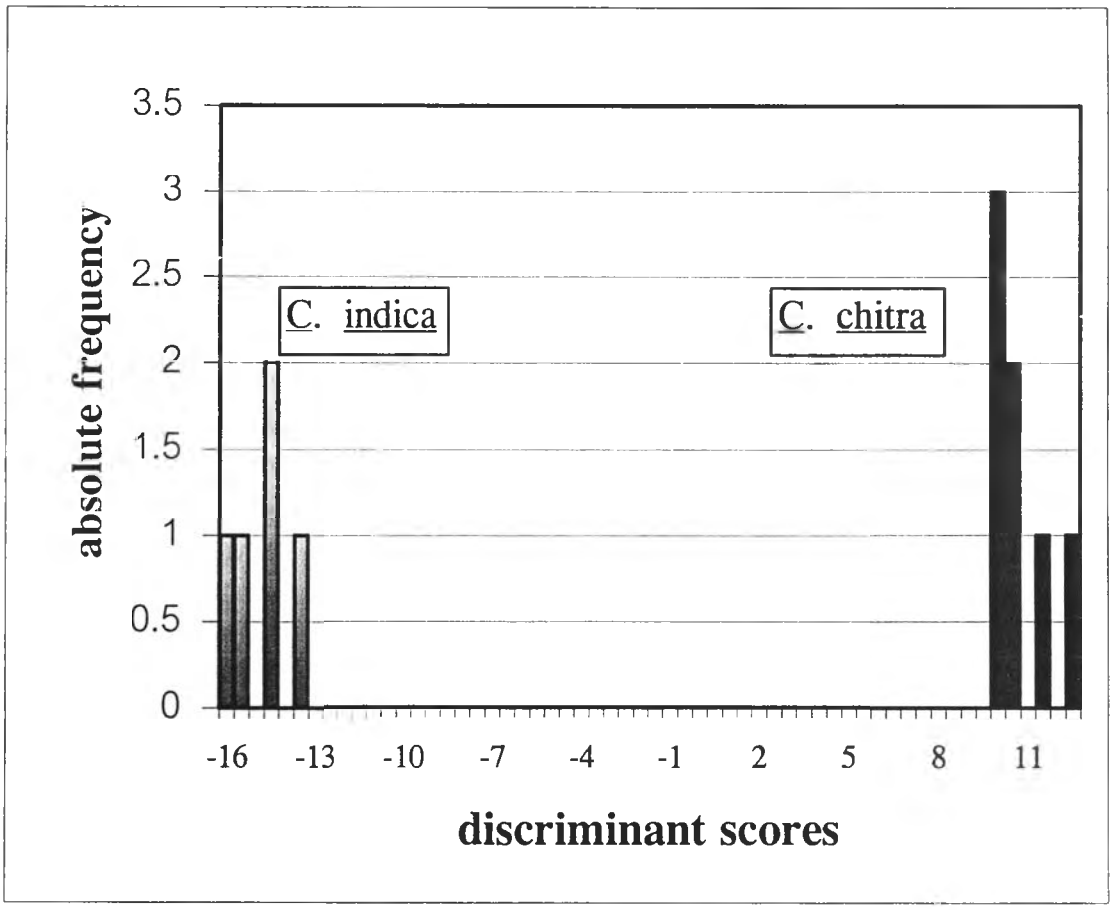

Figure 3.3 Discriminant scores of skulls vary from +10 to +12.5 in C. chitra and -13.5 to -16 in C. indica.

Therefore only those variables were employed for further function:

D (skull) = 211.481(SH/SW) – 519.047(NW/SW) – 673.041(RPFL/SW) + 639.521(RPFW/SW) +138.364(LPFW/SW) + 271.269(LPOL/SW) – 100.089(RPOW/SW) + 38.768

Where D $\geq$ -2.12 = C. chitra and D < -2.12 = C. indica

Carapace Analysis

The ratios of P3RW/BDL, P3LW/ BDL, N3W/ BDL and P7LW/ BDL were chosen as the best stepwise discriminant variables with 100% original grouped cases correctly classified (Table 3.3).

Table 3.3 Statistics of the carapace variables selected by forward stepwise discriminant analysis for species discrimination between C. chitra and C. indica. The variables were listed in order of entrance in the model.

Variable	step	Wilks' Lambda	Exact F	P
P3RW/CL	1	0.216	43.486	<0.000
P3LW/CL	2	0.108	45.278	<0.001
N3W/CL	3	0.057	54.868	<0.001
P7LW/CL	4	0.027	80.123	<0.001

The discriminant function for carapace variables was then created as the following:

D (carapace) = 160.663(N3W/ BDL) + 111.874(P3LW/ BDL) – 209.154(P3RW/ BDL) – 63.314(P7LW/ BDL) + 5.053

Where D $\geq$ -0.797 = C. chitra and D < -0.797 = C. indica

The discriminant scores of carapaces in Figure 3.4 have distinguished C. chitra from C. indica effectively.

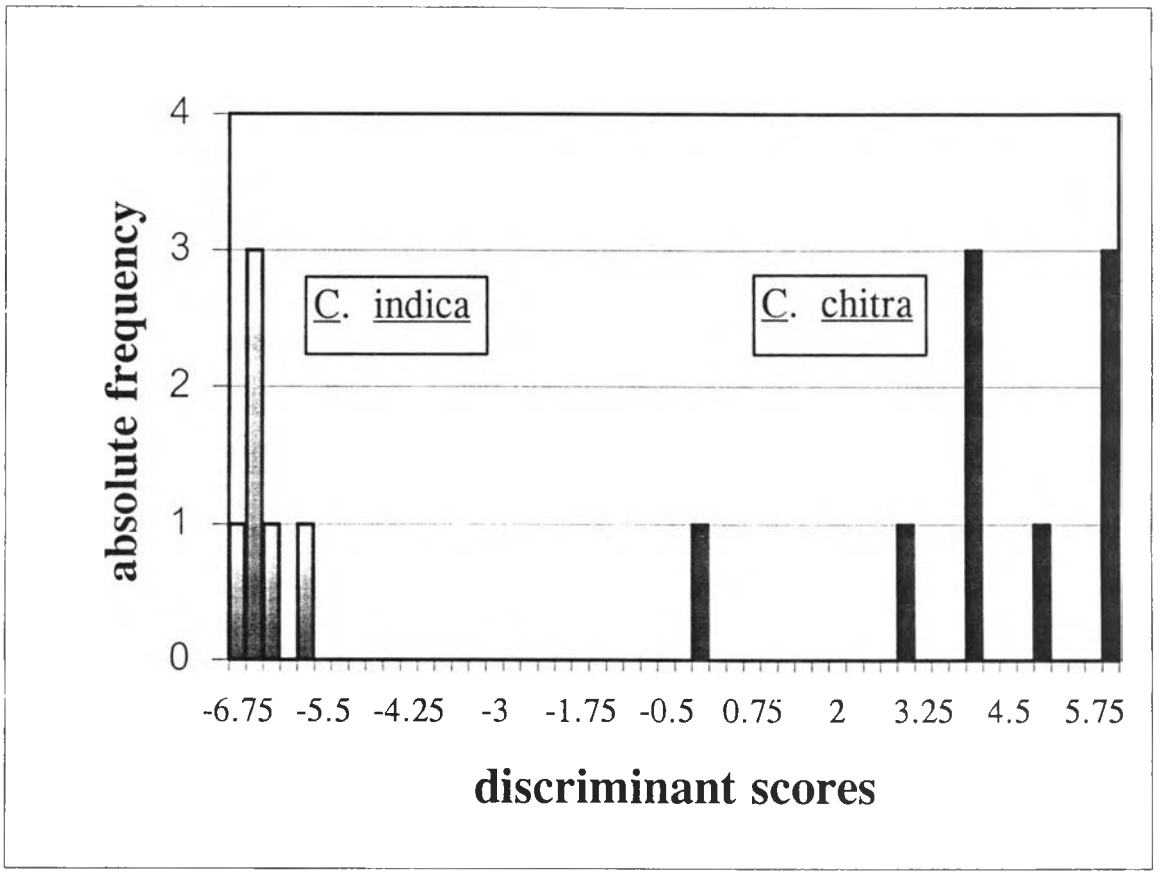

Figure 3.4 Discriminant scores of the carapaces vary from 0 to +6 in C. chitra and -5.5 to -6.75 in C. indica.

Discussion

There were 7 skull ratio characters and 4 carapace ratio characters were chosen as significant difference between C. chitra and C. indica. Discriminant scores of skulls and carapaces between C. chitra and C. indica also show non-overlapping distribution (Figure 3.3 and 3.4). Discriminant analyses of the skull and carapace characters selected provide strong evidence for the separation of C. chitra from C. indica and could be used to support the designation of the former as a valid species. Moreover, the recent study of phylogenetic analysis from the mitrochondial ND4 gene revealed deeply divergence between C. chitra and C. indica (Engstrom et al., 2002).

Furthermore, the discriminant functions of the skull and the carapace could be very useful for the confirmation of identity of unidentified specimens.

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References

Baillie, J., and Groombridge, B. (Eds.). 1996. IUCN Red List of Threatened Animals. Gland, Switzerland: IUCN.

van Dijk, P. P. and Thirakhupt, K. 1995. Southeast Asian Chitra. From Distinction to Extinction in 15 Years? In Soptom (Ed), Proceedings International Congress of Chelonian Conservation. Gonfaron France 6-10 July 1995.

Engstrom, T. N., Shaffer, H. B., and McCord, W. P. 2002. Phylogenetic diversity of endangered and critically endangered Southeast Asian softshell turtles (Trionychidae: Chitra). Biological Conservation. 104(2): 173-179.

Nutphand, W. 1986. "Man Lai" the world's biggest softshell turtle. Thai Zoological Magazine 1(4): 64-70. (in Thai)

Pritchard, P. C. H. 2001. Observations on body size, sympatry, and niche divergence in softshell turtles (Trionychidae). Chelonian Conservation and Biology 4: 5-27.

Smith, M. A. 1931. The Fauna of British India. Florida: Ralph Curtis Book.

Taylor, E. H. 1970. The turtles and crocodiles of Thailand and adjacent waters. The University of Kansas Science Bulletin. 49: 87-179.

Thirakhupt, K., and van Dijk, P. P. 1994. Species diversity and conservation of the turtles of Western Thailand. Natural History Bulletin of the Siam Society 42:209-259.

Appendix

Characters and their abbreviations

Skull

Skull height, SH; Skull length, SL; Skull width, SW; Right orbit length, ROL; Left orbit length, LOL; Nostril length, NL; Nostril width, NW; Right frontal length, RFL; Left frontal length, LFL; Right frontal width, RFW; Left frontal width, LFW; Right post-frontal length, RPFL; Left post-frontal length, LPFL; Right post-frontal width, RPFW; Left post-frontal width, LPFW; Right jugal length, RJL; Left jugal length, LJL; Right pro-otic length, RPOL; Left pro-otic length, LPOL; Right pro-otic width, RPOW; Left pro-otic width, LPOW; Right supraoccipital length, RSOL; Left supraoccipital length, LSOL; Right quadrate width, RQW; Left quadrate width, LQW; Right quadrate length, RQL; Left quadrate length, LQL.

Carapace

Nuchal width, NuW; Nuchal Length, NuL; Carapace Width, CW; Carapace Midline Length, CML; Carapace Length, CL; Neural1 width, N1W; Neural2 width, N2W; Neural3 width, N3W; Neural4 width, N4W; Neural5 width, N5W; Neural6 width, N6W; Neural7 width, N7W; Neural8 width, N8W; Neural1 length, N1L; Neural2 length, N2L; Neural3 length, N3L; Neural4 length, N4L; Neural5 length, N5L; Neural6 length, N6L; Neural7 length, N7L; Neural8 length, N8L; Pleural1 Right Width, P1RW; Pleural2 Right Width, P2RW;

Pleural3 Right Width, P3RW; Pleural4 Right Width, P4RW; Pleural5 Right Width, P5RW; Pleural6 Right Width, P6RW; Pleural7 Right Width, P7RW; Pleural8 Right Width, P8RW; Pleural1 Left Width, P1LW; Pleural2 Left Width, P2LW; Pleural3 Left Width, P3LW; Pleural4 Left Width, P4LW; Pleural5 Left Width, P5LW; Pleural6 Left Width, P6LW; Pleural7 Left Width, P7LW; Pleural8 Left Width, P8LW; Pleural1 Right Length, P1RL; Pleural2 Right Length, P2RL; Pleural3 Right Length, P3RL; Pleural4 Right Length, P4RL; Pleural5 Right Length, P5RL; Pleural6 Right Length, P6RL; Pleural7 Right Length, P7RL; Pleural8 Right Length, P8RL; Pleural1 Left Length, P1LL; Pleural2 Left Length, P2LL; Pleural3Left Length, P3LL; Pleural4 Left Length, P4LL; Pleural5 Left Length, P5LL; Pleural6 Left Length, P6LL; Pleural7 Left Length, P7LL and Pleural8 Left Length, P8LL.