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Description of a new subspecies of the crayfish *Parastacus brasiliensis* (Von Martens, 1869) from São Francisco de Paula, RS, Brazil (Decapoda, Parastacidae)

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Abstract

Parastacus brasiliensis promatensis **subsp. n.** is described from São Francisco de Paula, Rio Grande do Sul, Brazil. The animals were collected at an elevation of 850 m, representing the first record of Parastacidae at high altitude in Brazil. Subspecies recognition was performed through the analysis of morphometrical characters. Discriminant analysis was applied to compare *P. brasiliensis promatensis* **subsp. n.** with the known populations of *P. brasiliensis* (Von Martens, 1869) using residuals from 23 morphometric regressions (Canonical Correlation = 0.948). All variance was explained by function 1 ($P<0.001$), with perfect (100%) membership identification (*P. brasiliensis promatensis* centroid equal to 3.04; *P. brasiliensis* centroid equal to -2.78).

Key words: *Parastacus*, Parastacidae, Crustacea, Neotropical

Introduction

According to Crandall *et al.* (2000), the Parastacidae from South America are represented only by the genera *Parastacus* Huxley, 1879; *Samastacus* Riek, 1971 and *Virilastacus* Hobbs, 1991. There is a clear geographic segregation of the genera: *Parastacus* is found in southern Brazil, Uruguay, northern Argentina and Chile (two species), whereas *Samastacus* and *Virilastacus* are only found in Chile, in the western drainage of the Andes. The Brazilian species are *P. pilimanus* (Von Martens, 1869); *P. brasiliensis* (Von Martens, 1869); *P. varicosus* Faxon, 1898; *P. saffordi* Faxon, 1898; *P. defossus* Faxon, 1898 and *P. laevigatus* Buckup and Rossi, 1980 (Buckup, 1999).

Parastacus brasiliensis is a very common species described for the basins forming the Central Depression of Rio Grande do Sul, including tributaries of the Guaíba lake (Buckup, 1999). The present study aims to describe a subspecies of *P. brasiliensis*, captured at high altitudes and for a different basin system.

Material and methods

Parastacus brasiliensis promatensis **subsp. n.** was collected using baited fish traps in a creek (29º29.371’ S; 50º13.800’ W) located inside the Nature Research and Conservation Center of Pró-Mata, a private reserve (4.500 ha), established by PUCRS (Pontificia Universidade Católica do Rio Grande do Sul) in 1993 (São Francisco de Paula County, Rio Grande do Sul, Brazil).

Specimens of *P. brasiliensis* used for comparison were obtained from the Museum of Science and Technology of PUCRS (MCT) as follows: 1 specimen, Triunfo, RS, 1984 (MCT, 1041). 1 specimen, Sítio Bela

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Vista, Belém Novo, RS, 1975 (MCT, 1098). 19 specimens, Silveira Martins, RS, 1983 (MCT 996). 19 specimens, Nova Treviso, Faxinal do Soturno, RS, 1982 (MCT 979). 1 specimen, Gravataí, RS, 1986 (MCT 1110), 1 specimen, Parque Saint Hilaire, Porto Alegre, RS, 1973 (MCT 956). From now, the former known populations of *P. brasiliensis* will be named as *P. brasiliensis brasiliensis*.

Because of the morphological similarity between the new subspecies and *P. brasiliensis brasiliensis*, and lack of a clear morphological diagnosis, 23 morphometrical measurements (see Table 1 for definitions) were taken from 21 specimens of *P. brasiliensis promatensis* and 23 of *P. brasiliensis brasiliensis*. Gender was not treated separately due to unclear secondary sexual characters. Power regressions ($y=a.\text{Carapace\_Length}^{b}$) were applied to pooled data (*P. brasiliensis promatensis* and *P. brasiliensis brasiliensis*) to convert each measurement into residuals aiming to eliminate bias from individual size and allometric growth pattern. Regressions were performed using SPSS (11.0) non linear regression routine, using Levenberg-Marquardt algorithm to eliminate bias from log-transformation. Species were then compared using Discriminant Analysis (SPSS 11.0) applied to the complete set of residuals.

TABLE 1. Measurements and abbreviations used for the morphometrical analysis of *Parastacus brasiliensis promatensis* **subsp. n.** and *Parastacus brasiliensis brasiliensis*.

Symbol	Definition
HCHE	Height of cheliped
HPRO 5	Height of propodus (5th pereiopod)
LABD	Length of the Abdomen
LACAR	Length from cervical groove to rostral apex
LCAR 5	Length of carpus (5th pereiopod)
LCHE	Length of cheliped
LDAC	Length of the dactylus of the cheliped
LDAC 5	Length of dactylus (5th pereiopod)
LMER 5	Length of merus (5th pereiopod)
LPCAR	Length from cervical groove to the posterior border of the caparace
LPRO 5	Length of propodus (5th pereiopod)
LROS	Length of the rostrum (to the posterior orbital edge)
LSTEL	Length from the telson lateral spine to the anterior border of the telson
LTEL	Length of telson
LURO 1	Length of uropod 1 (endopodite)
LURO 2	Length of uropod 2 (exopodite)
TCHE	Thickness of cheliped
WCAR	Maximum width of the capace
WROS	Maximum width of the rostrum between rostral carenas
WTEL	Maximum width of the telson
WTELS	Width of the telson between the lateral spines
WURO 1	Maximum width of the uropod 1
WURO 2	Maximum width of the uropod 2

***Parastacus brasiliensis promatensis* subsp. n. (Fig. 1)**

Type material. Holotype: MCT 2085. 1 specimen, Brazil, Rio Grande do Sul, São Francisco de Paula, Pró-

Mata, Garapiá stream (29º29.371' S; 50º13.800' W), 22.xi.1997, Leg. M. Conter. Paratypes: MCT 2086. 8 specimens, same location as holotype.

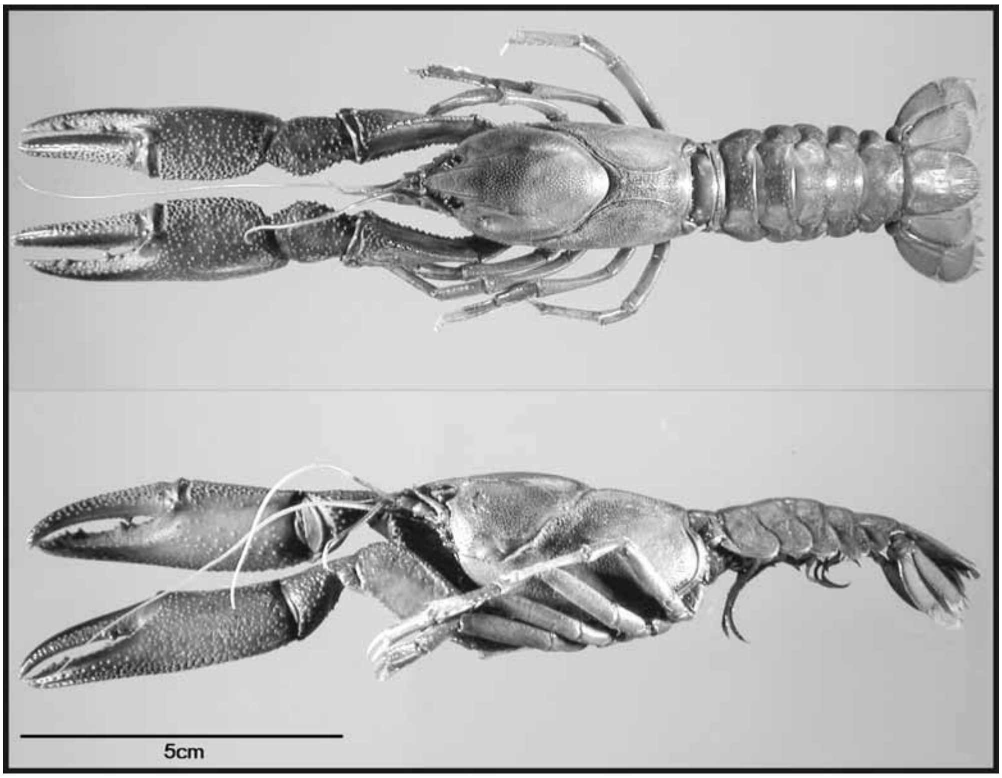

FIGURE 1. *Parastacus brasiliensis promatensis* **subsp. n.**

Etymology. The subspecies was named after the only location from where it is known.

Diagnostic characters. Identification should be based on a set of morphometrical data (Tables 2 and 3) as there is no morphological character that clearly distinguishes *P. brasiliensis promatensis* from *P. brasiliensis brasiliensis*.

TABLE 2. Morphometrical measurements of *Parastacus brasiliensis promatensis* **subsp. n.**.

Measurement	Average	SD	Maximum	Minimum
HCHE	10.45	3.17	18.00	5.00
TCHE	6.05	1.85	10.80	2.80
LCHE	26.27	9.75	52.20	11.70
LCAR5	4.86	1.39	7.90	2.60
LDAC5	3.63	0.86	5.20	2.30
LMER5	8.27	2.18	14.10	4.70
LPRO5	8.35	2.17	12.20	4.60
LCARAP	33.33	7.65	46.20	19.60
LABD	36.15	7.87	49.00	20.50
LROS	5.22	1.01	6.80	3.10
LTEL	11.15	2.65	15.60	6.10
LURO1	8.95	2.48	14.50	4.80
LURO2	10.64	2.74	16.00	5.70

TABLE 3. Ratios for morphometrical identification of *Parastacus brasiliensis promatensis* **subsp. n.**.

Ratio	Average	SD	Maximum	Minimum
Labd/Lcarap	1.0880	0.0430	1.2188	1.0310
Lros/Lcarap	0.1583	0.0159	0.2227	0.1432
Ltel/Lcarap	0.3340	0.0121	0.3596	0.3112
Luro1/Ltel	0.7984	0.0561	0.9932	0.7121
Luro2/Ltel	0.9510	0.0427	1.0959	0.9000
Hche/Lche	0.4097	0.0478	0.4710	0.2907
Tche/Lche	0.2382	0.0330	0.2774	0.1547
Lpro5/Lcar5	0.7492	0.0360	0.8248	0.6667
Ldac5/Lcar5	0.3287	0.0303	0.3868	0.2581
Lmer5/Lpro5	0.9936	0.0684	1.1949	0.9027

Description. Carapace laterally compressed, surface smooth, with small pores and scattered hairs. Subtriangular rostrum, usually extending up to the second segment of the antennula. Rostrum surface flat, edged by crests that converge to the apex, ending in a short and depressed spine. Long hairs, growing down to the orbit from the rostral margins. The aureole is narrower at the centre, with branchial crests anteriorly and posteriorly diverging. Palm long. Fingers are almost the same size, straight but converging distally, with small gap between them. Both fingers finish in a spinous processes and have small teeth on the cutting edges, with a larger tooth appearing on the proximal third. Abdomen smooth, with rounded abdominal pleura. Telson with lateral margins converging distally to a pair of spines and then finishing in a rounded posterior margin.

Holotype measurements. Height of right cheliped 13.5 mm, thickness of right cheliped 7.2 mm, length of rigth cheliped 32.4 mm, length of carpus (5th rigth pereiopod) 6.3 mm, length of dactylus (5th right pereiopod) 3.9 mm, length of merus (5th right pereiopod) 8.8 mm, length of propodus (5th right pereiopod) 8.9mm, length of the carapace 36.7 mm, length of the abdomen 40.6 mm, length of the rostrum (to the posterior orbital edge) 5.9 mm, length of telson 12.6 mm, length of uropod 1 (endopodite) 10.1 mm, length of uropod 2 (exopodite) 12.1 mm.

Maximum size. The largest of 750 captured and released animals was 9.7 cm long (total length measured from the tip of the rostrum to end of the telson).

Colour. The colour varies according to size and substrate. Small animals are usually sand-coloured. Large animals are darker, ranging from brown to dark olive, sometimes almost purple. Fingertips of the first pereopod are red or orange in large animals.

Morphometric Comparison of *P. brasiliensis promatensis* and *P. brasiliensis brasiliensis.*

Mean residuals and residual standard deviations derived from the adjusted power regressions ($y=a.\text{Carapace\_Length}^b$) are presented at Table 4. Comparison of mean residuals (ANOVA) between *P. brasiliensis promatensis* and *P. brasiliensis brasiliensis* resulted significant for 11 different measurements.

Discriminant analysis was applied to compare both species. All variance was explained by function 1 ($P<0.001$), with a Canonical Correlation of 0.948 and perfect (100%) membership identification. Centroid values for *P. brasiliensis promatensis* and *P. brasiliensis brasiliensis* was 3.04 and -2.78 respectively. Figure 2 shows frequency distribution of the Discriminant scores, showing that each animal could be perfectly identified through morphometrical data. Discriminant scores are also no affected by animal size, as could be seen through Figure 3.

Habitat. Garapiá stream drains a small basin with a thin acid soil layer over basalt rocks, covered by grass, natural and *Pinnus* forests. Basin area is about 3 km^2 through an altitude of 850m before a high water fall to the coastal plains. The species was not found in lower areas of the same basin. The width of the stream ranges from 0.5 m to about 3 m, with a maximum depth of 70-80 cm. The substrate varies from fine silt to sand and small rocks. Animals are found in hollows in the stream bank during the day.

TABLE 4. Mean residuals from power regressions (y=a.Carapace_Length^{b}) of pooled data of *Parastacus brasiliensis promatensis* and *Parastacus brasiliensis brasiliensis*. Regressions were performed using SPSS (11.0) non linear regression routine, applying Levenberg-Marquardt algorithm. Coefficients of the Canonical Discriminant function 1 are also presented (r=0.948).

	P. brasiliensis promatensis		*P. brasiliensis brasiliensis*		Significance for comparing means (ANOVA)	Coefficients of the Canonical Discriminant Function 1
Character	Mean	Std. Deviation	Mean	Std. Deviation		
HCHE	-0.01638	0.15623	0.02266	0.16803	0.43060	3.18313
HPRO5	-0.01293	0.07031	0.00739	0.10926	0.47216	-1.31597
LABD	0.02278	0.03526	-0.02387	0.04456	0.00043	11.44408
LACAR	0.00085	0.03247	-0.00077	0.01440	0.82937	-35.58309
LCAR5	-0.03060	0.11806	0.03315	0.11929	0.08244	-2.01322
LCHE	0.00852	0.11491	-0.00363	0.14961	0.76572	-8.31548
LDAC	0.01672	0.10657	-0.00887	0.12076	0.46208	12.15535
LDAC5	0.02801	0.10222	-0.02654	0.09230	0.06981	-0.53563
LMER5	-0.01828	0.07660	0.01787	0.08211	0.13956	-5.49672
LPCAR	-0.00105	0.03757	-0.00024	0.07585	0.96491	1.49908
LPRO5	0.02896	0.04731	-0.03079	0.07761	0.00399	12.47622
LROS	0.05558	0.05321	-0.05122	0.10055	0.00009	8.57633
LSTEL	0.04448	0.04459	-0.03912	0.04313	0.00000	21.80923
LTEL	0.04269	0.03550	-0.04025	0.04229	0.00000	11.45896
LURO1	0.01185	0.06364	-0.00673	0.06116	0.32905	8.83343
LURO2	0.01878	0.04321	-0.01148	0.05277	0.04472	-12.50582
TCHE	-0.02001	0.18231	0.02447	0.19067	0.43446	-4.15076
WCAR	0.00776	0.03775	-0.00513	0.04852	0.33404	7.09544
WROS	0.03735	0.05910	-0.03384	0.08647	0.00294	-0.05134
WTEL	0.04248	0.04534	-0.03411	0.04396	0.00000	13.29373
WTES	0.05249	0.08400	-0.05430	0.15678	0.00817	-1.99503
WURO1	0.00234	0.04338	-0.00212	0.05863	0.77738	-23.42223
WURO2	0.01424	0.06554	-0.01407	0.06075	0.14453	-8.97476
Constant						-0.00886

Discussion

Using the identification keys provided by Buckup and Rossi (1980) and Buckup (1999), *P. brasiliensis promatensis* is identified as *P. brasiliensis*. However, Discriminant analysis (Table 4, Fig. 2 and 3) are strong enough for a clear distinction between them, with perfect (100%) membership identification.

The relationship between both subspecies is very intriguing. Between them there is a geographical (60km) and altitudinal (650m) gap with no registered occurrence of any Parastacid. *Parastacus brasiliensis brasilien-*

sis is found in the central depression of Rio Grande do Sul (Jacuí Drainage), at altitudes of no more then 200m (estimated), characterized by sandstone sediments from Triassic. By the other hand, *P. brasiliensis promatensis* is found 850m high (Litoral Drainage), on a basalt basin formed during the Gondwana breakdown (lower Cretaceous). Of course, both subspecies are not so old. Cretaceous geological events may be related to vicariant process related to South American parastacoid genus formation, as reported by Crandall *et al.* (2000). Also, no major geological event is known from Cretaceous and Pleistocene climatic changes apparently do not justify this geographical gap.

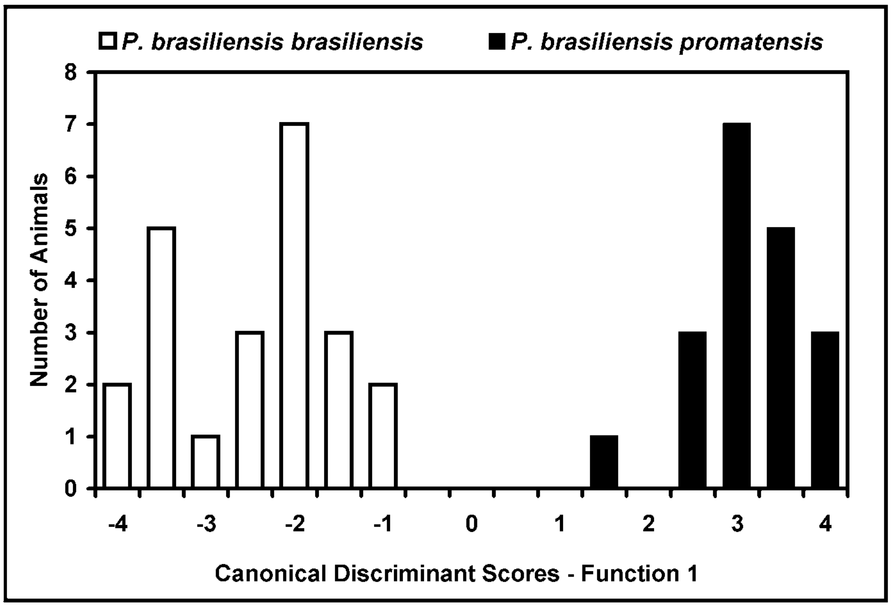

FIGURE 2. Frequency distribution of the Discriminant scores for individuals of *Parastacus brasiliensis promatensis* **subsp. n.** and *Parastacus brasiliensis brasiliensis*.

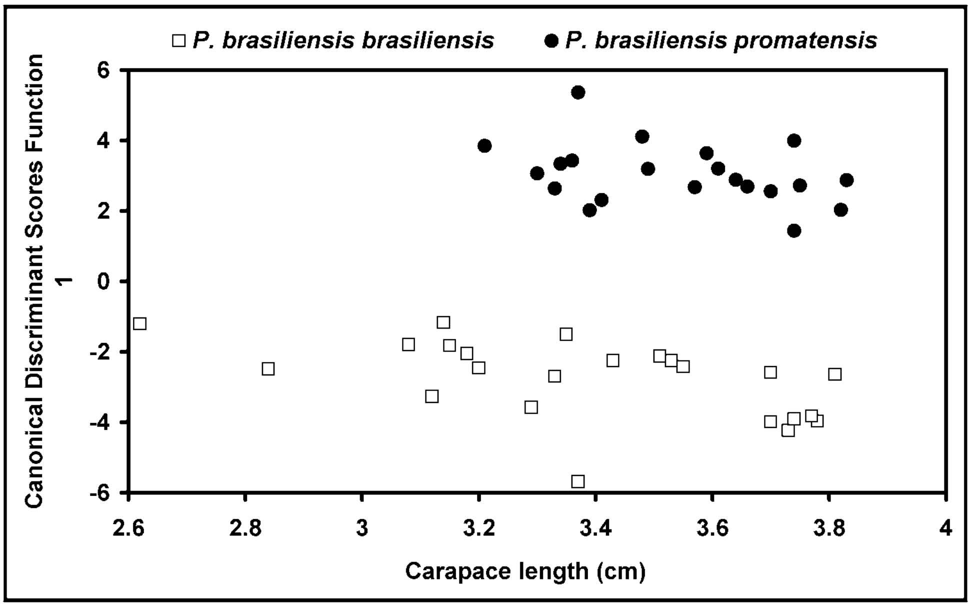

FIGURE 3. Discriminant scores for individuals of *Parastacus brasiliensis promatensis* **subsp. n.** and *Parastacus brasiliensis brasiliensis* as a function of the carapace length.

Parastacids are known to migrate outside water and to resist desiccation (Hughes & Hillyer 2003). Some years ago, an individual of *P. brasiliensis brasilienis* escaped from an aquarium in our lab and was found alive some (2-3) days before. The animal was so dehydrated that when returned to the water was unable to sink. Nevertheless, confined inside a hollow under water, in just some hours the animal was behaving as a healthy individual.

Parastacids can also move large distances using constructed or natural passages under the ground. We personally known a case of a very shallow (1,2m deep) water well constructed on a hill (100-200m) in sandstone sediments. The nearest creek was at least 500m distant and 20-30m bellow. After one year, the well was opened for cleaning and there were crayfishes (*Parastacus pilimanus*) living inside.

Hughes & Hillyer (2003) analysed, using molecular data, the patterns of connectivity among populations of *Cherax destructor* (Parastacidae) in Western Queensland, Australia. Although this species is able to terrestrial migration, these authors found almost no sharing of haplotypes across drainage boundaries, indicating limited terrestrial dispersal across them. Similar results were obtained by Nguyen e*t al.* (2005).

Crayfish dispersal between drainages was reported by Horwitz & Knott (1995) as food items frequently translocated by Australian aborigines. Amerinds also use crustaceans as regular food items, although with no record of *Parastacus* consumption.

So, the distribution of *P. brasiliensis brasiliensis* and *P. brasiliensis promatensis* so far apart is very interesting and maybe a molecular approach will be necessary to solve this biogeographical and evolutive question.

Acknowledgments

Jeter Bertoletti had informed us about the presence of a *Parastacus* population at Pró-Mata. Marcelo Barros and Gilson Fortes Rey made all the morphometrical measurements.

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