Allometric patterns in *Uca tangeri* males from an exploited population at San Pedro river, Andalucía, Spain.

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Abstract

Uca tangeri is the single existent European fiddler crab. Fishermen take the males' major claw off due to its high price in local markets. Such exploitation is thought does not affect population structure, since crabs are given back to the environment. Size at the onset of maturity was evaluated using relative growth analyses based on the allometry of the carapace and chelipeds. Intact males represented 51.1% of the sample, males with a regenerating cheliped represent 25% and males without the major claw 23.9%. Crabs with a regenerating claw biased both the allometric index and the regression coefficient. The estimated size at sexual maturity using the total of males was 18.0 mm carapace width, and 14.0 mm when regenerating males were excluded. Claw exploitation may change male *U. tangeri* behavior, since this appendage is very important during courtship and territory defense.

Key words: *Uca tangeri*, Ocypodidae, males, relative growth, exploitation.

Introduction

Burrowing and foraging activities of fiddler crabs promote bioturbation of estuarine intertidal flats, controlling the rate of detritus remineralization and promoting the microbiotic growth (Genoni, 1985). Males of *Uca* show a marked asymmetry of chelipeds. The developed claw has an important role for fiddler crabs, as it is used to attract females and also during inter and intraspecific male interactions.

Uca tangeri Eydoux, 1835 is the single fiddler crab species that occurs in the Eastern Atlantic, inhabiting Southern salt-marshes in Portugal and Spain, and those along the Northwestern coast of Africa down to Angola. In Southern Spain, the major claw of *U. tangeri* is commercialized and consumed as human food. Fishermen take this cheliped off and give crabs back to the environment.

The literature about this species is wide. In the Southern Iberian Peninsula, where the climate is temperate, *U. tangeri* remains underground during winter, when metabolic rate decreases and no crabs can be found foraging on the salt-marsh floor. In the beginning of spring (March and April) these crabs leave their burrows to feed. Gonad development is triggered and mating behavior evidences breeding activity. Several authors investigated *U. tangeri* due to its interesting geographic distribution and phylogenetic status (von Hagen, 1987; Wolfrath, 1992 a, b, 1993; Medina and Rodríguez, 1992; Medina, 1992; Rodríguez and Jones, 1993; Rodríguez *et al.,* 1997; Burford *et al.*, 2000 a, b; Oliveira *et al.*, 2000; Jordão and Oliveira, 2001).

The size at the onset of sexual maturity has been estimated using morphometric analyses by many authors (e.g., Hartnoll, 1982; von Hagen, 1987; Conde and Díaz, 1992; Pinheiro and Fransozo, 1993; Flores and Negreiros-Fransozo, 1999). Those researchers estimated the size at which the male pubert moult by detecting changes on the allometric growth of chelipeds. In the

U. tangeri population from River San Pedro, estimates of size at the onset of male sexual maturity can be biased since a significant proportion of those crabs bear a regenerating larger cheliped. Thus it is necessary to descriminate such individuals to perform allometric analyses. The aim of this study is to show how the inclusion of regenerating males may bias the estimation of size at onset of sexual maturity.

Material and Methods

This study was performed at the left margin of San Pedro River, an estuary from Andalucía, Southern Spain (Fig 1). This area is part of the Cádiz Bay National Park, and fishermen extract shellfish for their own consuption or local commerce. The major claw of *U. tangeri* is also an important fishery product in such region. In this work two people sampled the *U. tangeri* population by hand, during one hour in the low tide period. Fiddler crabs were frozen and afterwards males were sorted as normal, regenerating, and clawless. Carapace width (CW) and propod length (PL) of the larger cheliped were measured with a vernier caliper (0.01 mm). These values were graphed as a scatter plot to detect the probable size range at the onset of sexual maturity. Three groups were identified; i.e. juvenile males (JM), adult males with normal cheliped (NAM), and adult males bearing a regenerating claw (RAM). The power equation ($Y=aX^b$) was applied to each group and to the total adult males (TAM = NAM + RAM). Their isometric growth was tested by a *t*-test (Ho: b=1). The four equations were compared each other by covariance analyses and the *post hoc* Tukey test (Zar, 1996) was carried out for pairwise comparisons. The morphological sexual maturity analysis was performed in two different ways: first of all, the total of males was included and then the group of males with major cheliped in regeneration was removed. The detection of an inflection point was carried out with the aid of the software Mature I (Somerton, 1980). The statistic significance level used in all analyses was 5%.

Results

Frequency of males with a normal major cheliped was 51.1% (including juveniles), regenerating males comprised 25% of the sampled material, and males without claw comprised 23.9%. The TAM and RAM groups showed allometric index (b) equal to 0.80 and 0.86 respectively, indicating isometric growth rates, while JM and NAM showed a positive allometric growth (Table I). The four allometric equations differed statistically (ANCOVA, $p<0.05$). The size at onset of sexual maturity obtained using the total of males was 18.0 mm CW (F= 1.16, df: 2 and 117), and when the regenerating males were excluded, 14.0 mm CW (F=21.5, df: 2 and 94). The F value in the first case did not show statistical significance (p=0.32). Nevertheless, it was significant (p=0.000) when regenerating males were excluded. Figure 2 shows the relative growth patterns and the both values at onset of sexual maturity.

Table I: *Uca tangeri*: results of relative growth analyses for the relationship carapace width (CW) *vs* propod length (PL). JM: juvenile males, NAM: normal adult males, RAM: regenerating claw adult males, and TAM: total adult males.

Relationship	Group	N	a	b	Allometry	Test t Ho: b=1	r^2
	JM	45	0.295	1.40	Positive	p = 0.000	0.98
CW *vs* PL	NAM	53	0.135	1.74	Positive	p = 0.000	0.94
	RAM	22	1.153	0.86	Isometry	p = 0.581	0.36
	TAM	72	2.253	0.80	Isometry	p = 0.392	0.13

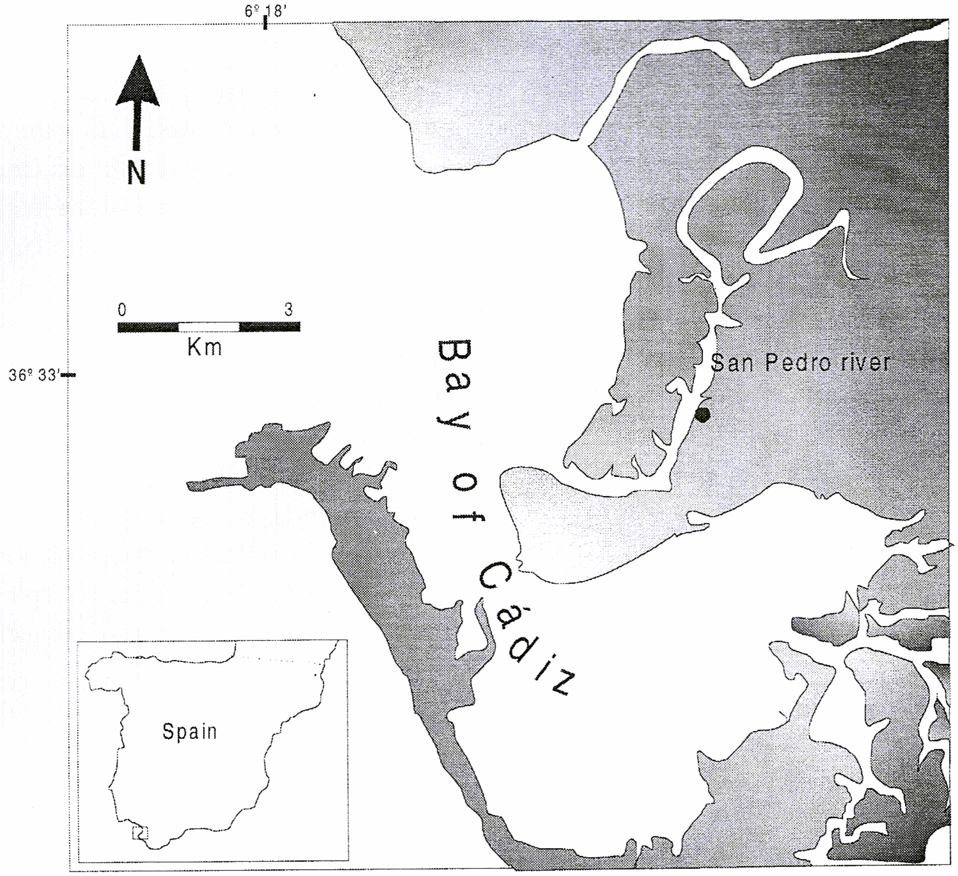

Figure 1: Sample area. San Pedro River, Andalucia, Spain.

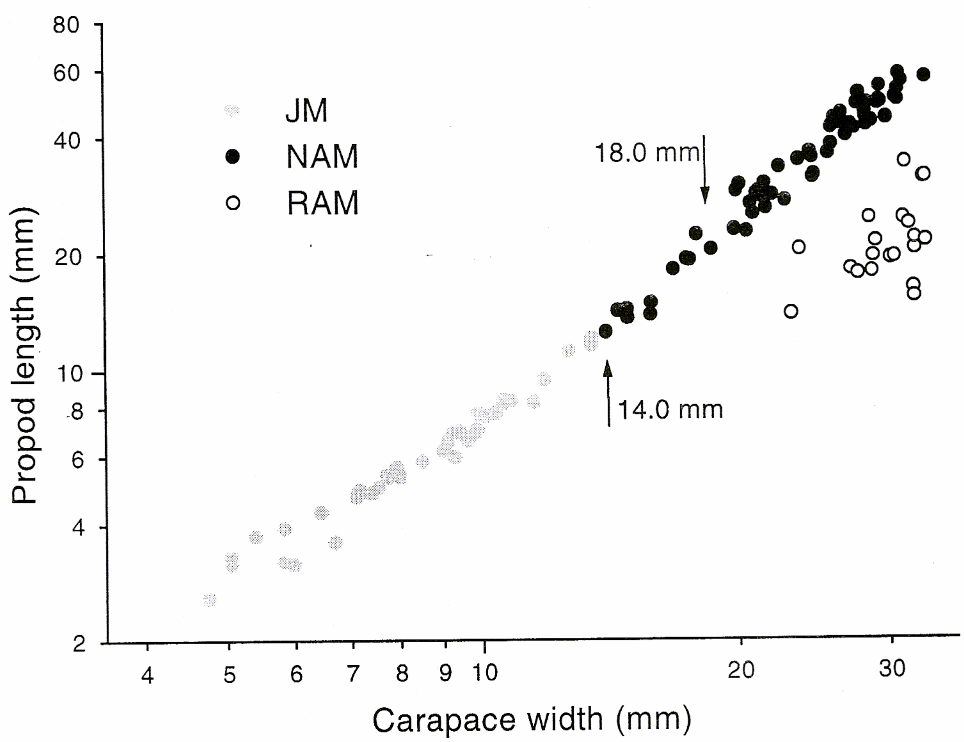

Figure 2: *Uca tangeri*: scatter plot showing for three groups (JM: juveniles males, NAM: normal adult males, and e RAM: regenerating claw adult males). The estimated size at the onset of sexual maturity, using the total of males (18.0 mm CW) and excluding the regenerating males (14.0 mm CW), are indicated by arrows.

Discussion

The species *Uca tangeri* is an abundant macrobenthic crustacean from San Pedro River (Rodríguez *et al.*, 1997). Touristic activities and seafood consumption increase during the summer in Southern Spain. At this time, fishermen capture *U. tangeri* males and take off the major cheliped due to their high price in local markets. Afterwards these crabs are given back to the population. In *Uca* species, the claws of males are markedly asymmetric with the larger claw attaining 40% of body weight (Rosemberg, 1997). Throughout the evolutionary history of this genus, the large appendage lost its feeding role. Extant species bear a hypertrophied cheliped for agonistic interactions with other males and/or to attract females to mate (Jordão and Oliveira, 2001). Several authors observed that females prefer males with larger chelipeds: Greenspan (1980) in *U. rapax*, Christy (1983) in *U. pugilator*, Backwell and Pasmore (1996) in *U. annulipes*, Oliveira and Custódio (1998) in *U. tangeri* and Latruffe *et al.* (1999) in *U. tangeri*. Such males also take advantages in their interactions. This attractive appendage may improve the males' reproductive success, but this implies in an elevated energetic cost. Besides the predation risk is higher in those individuals, which are slower tham females and they were more conspicuous to visual predators (Jordão and Oliveira, 2001). Males of fiddler crabs have just one feeding cheliped, thus spending more time foraging than females (Caravello and Cameron, 1987).

The loss of the major cheliped can imply in a decreased growth rate since energy is allocated to claw regeneration. Locomoting, feeding and moulting activity in *Uca tangeri* is enhanced from March to August, so, complete recovering of the cheliped takes a considerable time (Wolfrath, 1993). The percentage of *U. tangeri* males with a regenerating cheliped is high and their use for relative growth purposes can blur the actual growth pattern in this population. The relationship CW *vs* PL-TAM (total of adult males) shows a slower allometric index ($b = 0.80$) than adult males with normal claw ($b = 1.74$), showing that regenerating males biased the allometric equation and, consequently, the size at onset of the maturity. Therefore it is necessary to consider the fishery effect on these analyses. The loss of the largest cheliped can also affect the reproductive process decreasing the male potential for mating and territory defense (Wolfrath, 1993).

Estimating the size at the onset of sexual maturity using morphometric date is ofter advisable. However, physiological and/or histological analyses would be also needed, especially in *U. tangeri* that shows a particular reproductive cycle, different from any other tropical fiddler crab species, e.g. *U. vocator* studied by Colpo and Negreiros-Fransozo (2003), *U. thayeri* and *U. uruguayensis* by Costa (2000).

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