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Tentacle club length and body condition in the cuttlefishes *Sepia elegans* Blainville, 1827 and *Sepia orbignyana* Férussac, 1826 (Cephalopoda: Sepiidae)

Giambattista Bello

Arion, C.P. 61, 70042 Mola di Bari, Italy

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Abstract

The hypothesis that size of tentacle clubs – the organs by which decabrachian cephalopods catch prey – has some effects on the quantity of food caught and ingested was tested in four somatically distinct groups of cuttlefish, namely males and females of both *Sepia elegans* and *Sepia orbignyana*. To this purpose the relationship between individual body condition, which is the result of diet over time, and relative club length was examined. A statistically significant positive correlation was found between relative body condition factor, $K_n = W/a\mathrm{ML}^b$ (where W is the individual cuttlefish body mass, ML is the individual mantle length, and a and b are the parameters of the body mass–mantle length regression) and relative tentacle club condition factor, $T_n = \mathrm{CL}/c\mathrm{ML}^d$ (where CL is the observed value of club length, ML is the individual mantle length, and c and d are the parameters of the club length–mantle length regression). On average, a 10% departure of club length from its expected value causes a slight, proportionally direct departure of body mass from its expected value in the range of 1.6–2.0%, according to sex and species. The demonstration of such a correlation in four distinct cuttlefish groups corroborates the existence of an actual cause–effect relationship between relative tentacle club length and condition. Accordingly, it may be supposed that the character 'club length' is affected by natural selection.

Keywords: Cephalopoda; *Sepia elegans*; *Sepia orbignyana*; Tentacle club; Condition; Morphometrics

1. Introduction

Tentacle clubs are the organs by which decabrachian cephalopods capture their prey (e.g. Messenger 1968; Foyle and O'Dor 1987). It follows that quality, quantity and size of captured prey items largely depend on the morphology and size of tentacle clubs (Hanlon and Messenger 1996). In particular, it is most likely that within each species club size directly affects the capability of seizing prey, both in terms of prey size (i.e. larger clubs can catch larger prey items) and in terms of success in seizing attempts.

The purpose of this paper is to investigate whether tentacle club length has any influence on body condition of individual cuttlefish.

Body condition is a measure of the physical status of an animal. It largely depends on diet – as for cephalopods see Dawe (1988) and Moltschaniwskyj and Martínez (1998) – and represents an estimate of foraging success and fitness (Jakob et al. 1996); in a sense it

E-mail address: giabello@libero.it.

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records the cumulative effects of ingested food over time. Condition is usually estimated as body mass scaled by body size or a component of body mass that is independent of body size (see review by Pope and Kruse 2006). This is referred to as the condition index and is based on the assumption that the well-being of an animal is greater when it is heavier, rather than lighter, at a given length.

The general hypothesis tested in this study is that, in cuttlefishes, relative tentacle club length affects the quantity of food caught and ingested, which in turn affects body condition and growth rates (see Boletzky (1974) and Moltschaniwskyj and Martínez (1998) on the effects of diet on cephalopod growth). It is investigated whether individual cuttlefish with tentacle clubs longer than average are in a significantly superior physical condition, viz. their body mass is higher than average; conversely, individuals with tentacle clubs shorter than average are in an inferior physical condition, viz. their body mass is lower than average.

The study was carried out on *Sepia elegans* Blainville, 1827 and *Sepia orbignyana* Férussac, 1826 (Cephalopoda: Sepiidae). In order to avoid any sex-related biases, each sex of each species was treated as a distinct class of individuals. The different body proportions in the two sexes of both cuttlefish species – body mass/mantle length (Bello 1988), tentacle club length/body size (Bello 1991; Bello and Piscitelli 2000), cuttlebone width/cuttlebone length (Neige and Boletzky 1997) – in fact distinguish each sex of each species as a somatically distinct entity.

2. Materials and methods

2.1. Study species and measurements

Four somatically different groups of cuttlefish were used: males and females of *S. elegans*, and males and females of *S. orbignyana*. The cuttlefish were sampled by bottom trawl at depths ranging from 100 to 160 m in the south-western Adriatic Sea, in an area off Mola di Bari, over a period of about 3 weeks in May 1999. Specimens collected in such a restricted area and within a restricted period of time should be minimally affected by bias in biological parameters due to geographical, depth (Mangold 1982), and seasonal differences (Dawe 1988).

Only cuttlefish with measurable mantle length, i.e. with unbroken cuttlebone, and at least one tentacle club in place were retained. The examined sample consisted of 64 males and 65 females of *S. elegans*, and 64 males and 64 females of *S. orbignyana* (size ranges are reported in Table 2).

Measurements were taken following freezing overnight and defrosting cuttlefish; this procedure ensures full club relaxation. Lengths were recorded by clock caliper. The following measurements were taken (Roper and Voss 1983): ML is the dorsal mantle length, to 0.01 cm; W the body mass less stomach content weight, to 0.01 g (the weight of stomach contents was subtracted from the total body mass in order to eliminate this possible source of sampling variability); CL the tentacle club length, to 0.01 cm (the CL of each specimen is the average length of the two clubs or the individual measure in case of a missing club; cf. the 2nd paragraph of this section).

2.2. Statistical treatment of data

Two different approaches were adopted to investigate the relationship between tentacle club length and body mass.

(A) First, an established method, i.e. the examination of partial correlations, was carried out to show the occurrence, if any, of a relationship between CL and W independent of body length.

The partial correlation coefficient measures the correlation between any pair of variables when other variables are held constant (Sokal and Rohlf 1981). In the present case, the partial correlation coefficient $r_{(W\,\mathrm{CL})\cdot\mathrm{ML}}$ measures the correlation between body mass and tentacle club length when mantle length is held constant. The computation of the partial correlation coefficient is based on the correlation coefficients of the correlation between body mass and tentacle club length $r_{W\,\mathrm{CL}}$, the correlation between body mass and mantle length $r_{W\,\mathrm{ML}}$, and the correlation between tentacle club length and mantle length $r_{\mathrm{CL\,ML}}$, according to the formula:

$$r_{(W\,\mathrm{CL})\cdot\mathrm{ML}} = \frac{(r_{W\,\mathrm{CL}} - r_{W\,\mathrm{ML}} \cdot r_{\mathrm{CL\,ML}})}{\sqrt{(1 - r^2_{W\,\mathrm{ML}})(1 - r^2_{\mathrm{CL\,ML}})}}.$$

Then the significance level P associated to the r value is derived by means of the t-distribution (with n–2 df) by using the standard error of the correlation coefficient r: $t_{(s)} = r\sqrt{(n-2)/(1-r^2)}$ (Sokal and Rohlf 1981).

The examination of partial correlations only shows whether there is a relationship independent of body length between tentacle club length and body mass. In order to assess quantitatively the effects of CL on W, the following novel approach based on condition indices was adopted.

(B) The condition index herein adopted for cuttlefish is the relative condition factor, K_n, that is the ratio between the observed individual body mass, W, and expected individual body mass, $\hat{W}$, as derived by the 'body mass–mantle length' regression $\hat{W} = a\mathrm{ML}^b$; hence $K_n = W/\hat{W}$ or $K_n = W/a\mathrm{ML}^b$ (Pope and Kruse