Rare sexual anomalies in *Temora stylifera* (Dana, 1849) (Copepoda: Calanoida)

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(With 2 figures)

Temora stylifera (Dana, 1849) is one of the most abundant species of calanoid copepods in neritic waters off Brazil (e.g. Neumann-Leitão et al., 1999). This species has a circumglobal distribution in tropical and subtropical waters (Bradford-Grieve et al., 1999), and has been studied in several aspects such as morphology, feeding ecology and reproductive biology (see Turner et al., 2001).

Antennule (A1), fifth leg (P5), genital somite complex and urosome somites usually contain distinguishable sexual characters that display dimorphism in the order Calanoida. In most calanoid species the geniculated A1 is used for mate recognition and initial capture of the female, by grasping its caudal rami or setae (Ohtsuka and Huys, 2001). Generally, the right side is the geniculate and prehensile appendage, presenting one or two hinged joints, which enables the antennule to fold back upon itself (Blades-Eckelbarger, 1991), a common pattern in numerous families including the Temoridae. In *Temora stylifera* (Dana, 1849), antennular segments 17 to 19 are modified and segments 18 and 19 are separated by a hinge that allows extension and flexion, used for clasping the female (Corni et al., 2001). The male urosome of calanoid copepods is characterized by having five or, less frequently, four somites and the absence of fusion forming complexes. Females generally display only three or four articulating elements, the first corresponding to a dilated genital double somite, formed by the fusion of the genital and first abdominal somites (Ferrari and Dahms, 2007).

Numerous morphological and sexual anomalies including congenital malformation, intersexuality, gynandromorphism, parasitic castration and sex change have been described in calanoid copepods (e.g. Bayly and Shiel, 2008). Nevertheless, double geniculation of A1 was not documented in extant calanoid and intersex or gynandromorphic individuals of *Temora stylifera* (Dana, 1849) have not been described until this moment. We report two anomalous specimens found in the Southern Brazilian Bight (Table 1), showing distinct abnormalities in sexually relevant morphological features. Voucher and anomalous specimens were deposited at the Museu de Zoologia at Universidade de São Paulo (MZ USP number 18856).

1) *Gynandromorphic individual*: the animal had a female genital somite and reproductive structures including ovary and oviducts. The remaining sexual characters such as A1 and fifth leg (P5) were typically male (Figure 2); and
2) *Male bearing geniculation in both antennules*: the specimen was observed alive in microcosms and displayed similar swimming behavior when compared to normal males. This animal did not show any other morphological abnormalities in addition to the double geniculation of A1 (Figure 1). The antennules were symmetrical, showing an identical number of segments, geniculation pattern and size. The configuration of the setae and modified segments follows that described by Corni et al. (2001) for both specimens.

The gynandromorphic individual anomaly was not induced by parasites since detailed examination showed

Table 1. Collection details and sampling sites in the Southern Brazilian Bight where the anomalous specimens were found.

	Specimen 1	**Specimen 2**
Coordinates	23° 07' 85'' S and 43° 56' 03'' W	23° 31' 37'' S and 45° 05' 07'' W
Local depth (m)	32	40
Sampling depth (m)	20	15-20
Net mesh (μm)	300	200
Sampling date	August 2002	March 2007

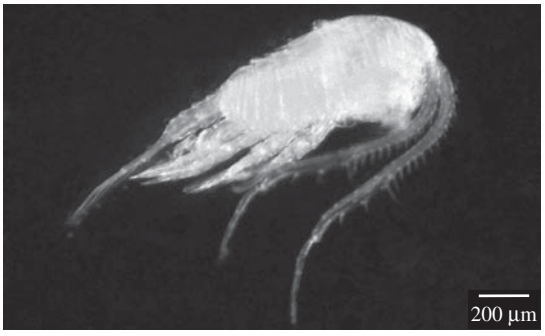

Figure 1. Anomalous male of *Temora stylifera*, bearing geniculation on both antennules.

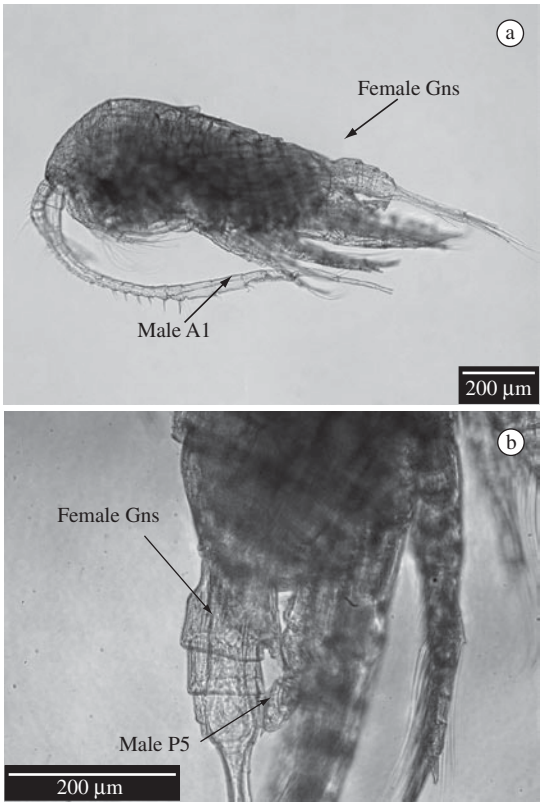

Figure 2. Aberrant individual displaying male characters and a female double genital somite complex (Gns). a) whole specimen; and b) detail of female Gns and male P5.

no evidence of infections. How the anomalous characters found in this study had developed remains unknown. Intersexuality is often found in P5 (e.g. Ianora et al., 1987), or A1 (e.g. Flemminger, 1985) rather than on the genital somite. Intersex individuals were described in species of Acartidae, Calanidae, Diaptomidae, Euchaetidae, Metridinidae and Paracalanidae (Ferrari, 1985 among others). Similar data has not been found for the Temoridae and we cannot confirm that the gynandromorphic specimen is an intersex. The fact that A1 and P5 are identical to male appendages is not an ordinary pattern in intersex individuals as well.

Geniculation in both antennules is common in cyclopoid families, such as Fratiidae, Cyclopidae and Cyclopinidae (Boxshall and Halsey, 2004), but not in calanoids. This is the first report of geniculation on both male antennules. The rare geniculation anomaly found here could be interpreted as evolutionary evidence, as it resembles the copepod ancestral condition (Boxshall and Huys, 1998; Huys and Boxshall, 1991). Few studies have documented sexual anomalies in copepods and their causes. Intersexuality is a widespread phenomenom in copepods and might be related to food limitation (Gusmão and McKinnon, 2009 accepted). Aberrant animals are often taken as sexually non-functional individuals, meaning that their occurrence might have consequences to copepod population dynamics. Further research must be carried out on these abnormalities and their behavioral consequences to fully understand their ecological impact.

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References

BAYLY, IAE. and SHIEL, RJ., 2008. Intersexuality in *Boeckella triarticulata* (Thomson, 1803) (Copepoda, Calanoida): a trap for unwary taxonomists. *Crustaceana*, vol. 81, no. 3, p. 299-304.

BLADES-ECKELBARGER, PI., 1991. Functional morpholgy of spermatophores and sperm transfer in calanoid copepods. In BAUER, RT. and MARTIN, JW. (Eds.). *Crustacean sexual biology*. New York: Columbia University Press. p. 246-270.

BOXSHALL, GA. and HALSEY, SH., 2004. *An introduction to copepod diversity*. London: Ray Society. 966p.

BOXSHALL, GA. and HUYS, R., 1998. The ontogeny and phylogeny of copepod antennules. *Philosophical Transactions of the Royal Society of London B: biological sciences*, vol. 353, no. 1369, p. 765-786.

BRADFORD-GRIEVE, JM., MARKHASEVA, EL., ROCHA, CEF. and ABIAHY, B., 1999. Copepoda. In BOLTOVSKOY, D. (Ed.). *South Atlantic Zooplankton*. Leiden: Backhuys Publishers. p. 869-1098.

CORNI, MG., VIGONI, V. and SCANABISSI, F., 2001. Some ultrastructural features of the reproductive morphology and spermatophore placement of *Temora stylifera* Dana, 1849 (Copepoda: Calanoida). *Crustaceana*, vol. 74, no. 1, p. 79-90.

FERRARI, F., 1985. Postnaupliar development of a looking glass copepod, *Pleurommama xiphias* (Giesbrecht, 1889), with analyses of distributions of sex assimetry. *Smithsoniam Contributions to Zoology*, no. 420, p. 1-55.

FERRARI, F. and DAHMS, HU., 2007. *Post-embryonic development of the Copepoda*. Leiden; Boston: BRILL ed. Crustaceana monographs 8.

FLEMMINGER, A., 1985. Dimorphism and possible sex change in copepods of the family Calanidae. *Marine Biology*, vol. 88, no. 3, p. 273-294.

GUSMÃO, LFM. and MCKINNON, DA. 2009. Sex ratios, intersexuality and sex change in copepods. *Journal of Plankton Research*, accepted)

HUYS, R. and BOXSHALL, GA., 1991. *Copepod evolution*. London: Ray Society. 468p.

IANORA, A., MAZZOCHI, MG. and SCOTTO Di CARLO, B., 1987. Impact of parasitism and intersexuality on Mediterranean populations of *Paracalanus parvus* (Copepoda: Calanoida). *Diseases of Aquatic Organisms*, vol. 3, p. 29-36.

NEUMANN-LEITÃO, SN., GUSMÃO, LMO., SILVA, TA., NASCIMENTO-VIEIRA, DA. and SILVA, AP., 1999. Mesozoplankton biomass and diversity in coastal and oceanic waters off North-Eastern Brazil. *Archive of Fishery and Marine Research*, vol. 47, no. 2-3, p. 153-165.

OHTSUKA, S. and HUYS, R., 2001. Sexual dimorphism in calanoid copepods: morphology and function. *Hydrobiologia*, vol. 453-454, no. 1, p. 441-466.

TURNER, JT., IANORA, A., MIRALTO, A., LAABIR, M. and ESPÓSITO, F., 2001. Decoupling of copepod grazing rates, fecundity and egg-hatching success on mixed and alternating diatom and dinoflagellate diets. *Marine Ecology Progress Series*, vol. 220, p. 187-199.