Modelling bite force in insects: comparison of different PCSA approaches with *in vivo* measurements

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Abstract. Physiological cross sectional area (PCSA) is a pivotal biomechanical variable, which allows to model muscle force, and in turn individual performance. In insects, PCSA is usually measured via 3D methods[1,2], which have not been tested against the dissection derived baseline. Studying the mandible muscles of the grasshoper, we show that PCSAs are not the same depending on the method used. This may be explained by the muscle density constant used or by shrinkage, but it highlights that 3D PCSA estimates may not be correct. Only dissection derived estimates correlate with *in vivo* bite forces.

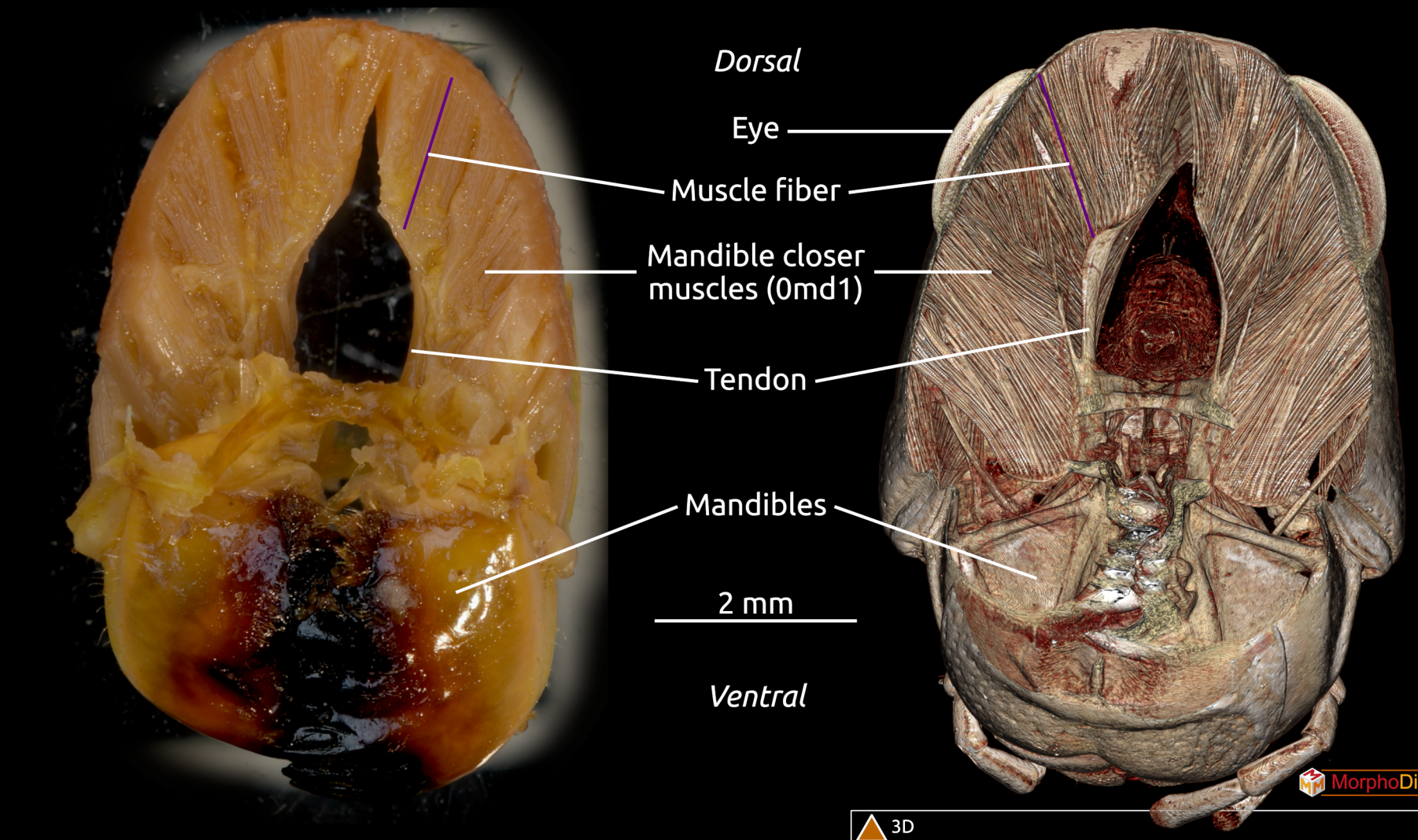

Figure 1. Dissection (left) and 3D volume rendering section (right) of *Schistocerca gregaria*. From the dissected specimens', muscles were weighed and fibers were dissected and measured. From the 3D specimens, muscle volume and fiber length were directly measured (e.g. using MorphoDig[3]).

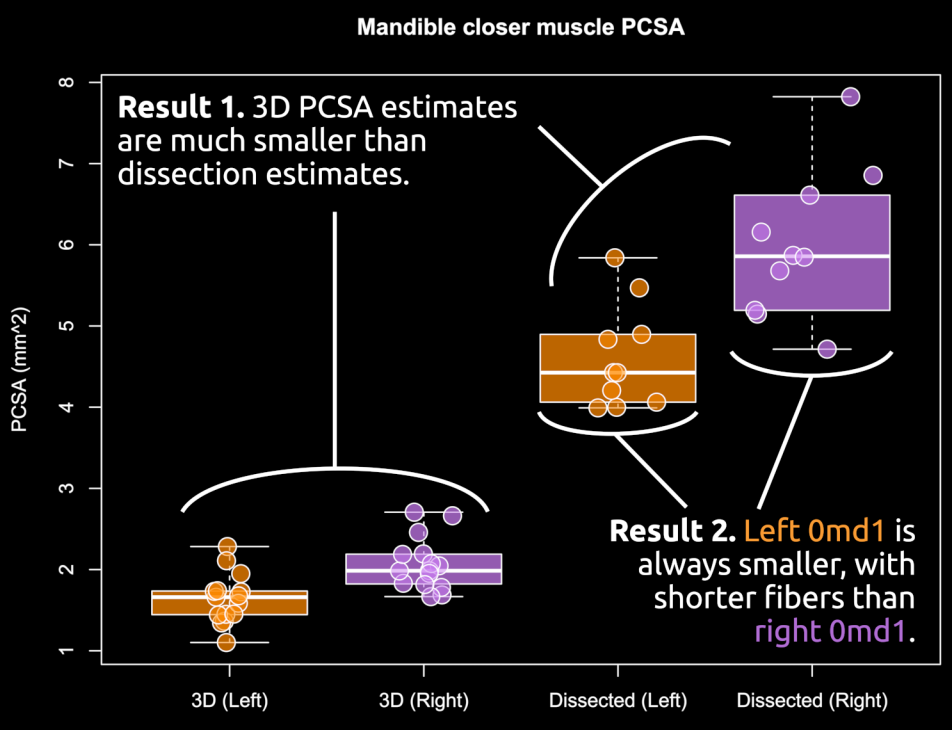

Figure 2. Boxplots of PCSA values obtained from 3D data (N=15) and dissections data (N=10). Points show values for individual muscles.

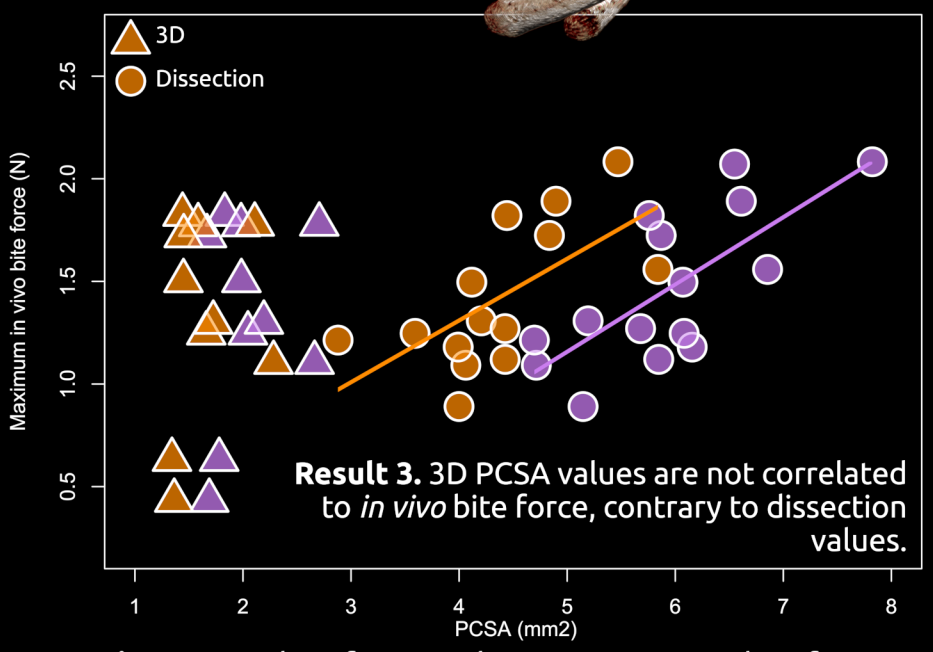

Figure 3. Biplot of PCSA values against *in vivo* bite forces.

Discussion. 3D methods have the potential to automatize muscular measurements[4]. Our results show that the various methods being developed should be carefully benchmarked against traditional ones to ensure that derived biomechanical models are comparable. Although PCSAs values differ (Fig. 2), fiber lengths were the same (not shown) suggesting that 3D PCSA biases could be corrected in the future, allowing to quickly produce accurate biomechanical models of *in vivo* performance.

References.

1. Goyens et al. (2014). *J. Exp. Biol. 217*, 1065-1071.
2. Weihmann & Wipfler (2019). In: Insects Mouthparts, Springer.
3. Lebrun, R. MorphoDig. IPC5, Paris, France, 07/2018.
4. Katzke et al. (2022). *Integ. Org. Biol.*