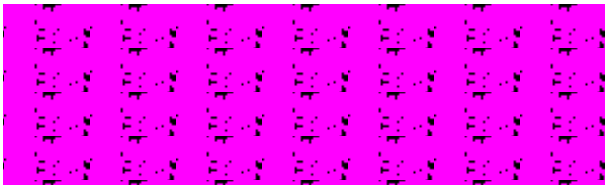

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The impediment of sex on taxonomy: A case study in macaque monkeys

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Abstract

Previous work indicates that the taxonomic signal of a given skeletal element largely depends on the degree of sexual dimorphism present. In other words, it may be the case that sexual dimorphism confounds taxonomy. Here, we investigate this phenomenon in the relatively specious and sexually dimorphic macaque (*Macaca*) monkey, testing whether there was a significant interaction between sex and species throughout the skeleton. If such interaction were found, we explored how to control the effects of sex on morphology for more accurate taxonomic assessment.

Data included 3D scans from wild, adult males and females for nine representative species (*n*=297): *M. arctoides* (17 M, 20 F), *M. fascicularis* (21 M, 20 F), *M. fuscata* (20 M, 20 F), *M. mulatta* (14 M, 25 F), *M. nemestrina* (21 M, 23 F), *M. nigra* (9 M, 15 F), *M. radiata* (11 M, 13 F), *M. sylvanus* (4 M, 4 F) and the outgroup *Trachypithecus cristatus* (20 M, 20 F). 293 fixed and semilandmarks were applied to eight skeletal elements for each individual (crania=45; mandible=31; scapula=66; humerus=38; radius=33; os coxa=28; femur=40; tibia=40). Landmark data for each bone were imported into *MorphoJ* to perform a Procrustes Analysis

of Variance (ANOVA); results that reported a significant interaction term ($p<0.05$) between the two main variables, sex and species, suggested that taxonomy was impacted by sexual dimorphism. All bones tested except for the radius and tibia reported $p<0.05$, indicating that the majority of bones exhibit differing patterns of sexual dimorphism among species. This means that methods for controlling for sexual dimorphism such as a multivariate regression, where the independent variables are shape and the dependent variable is sex, may not be sufficient to control for the effects of sexual dimorphism across all taxa. Hence, additional methods for controlling for species-specific patterns of sexual dimorphism may be required when attempting to reconstruct taxonomic affiliation from skeletal morphological data.

Thus, here we demonstrate the strong effect of sex on morphology in sexually dimorphic species like macaques. Given that the majority of bones returned a significant interaction term, we suggest that any future study investigating taxonomic valence first test for the effect of sex on species. Moreover, we recommend that future work focus on methods to best to control for the impact of sex on morphology, specifically in taxonomic studies.

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