EVOLUTION OF POLYUNSATURATED FATTY ACID BIOSYNTHESIS IN COPEPODS

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Throughout their evolution, copepods (Copepoda, Crustacea) have successfully adapted to a wide range of marine and freshwater habitats each characterized by specific trophic conditions. Copepods are generally known to contain high levels of polyunsaturated fatty acids (PUFAs), notably omega-3 long-chain PUFAs such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). It was long assumed that copepods acquired PUFAs through the food chain, but recent research shows some species can biosynthesize them endogenously. However, the extent to which the copepods' perceived capacity of PUFA biosynthesis coincides with their diversification and niche specialization remains undocumented. Leveraging publicly available copepod transcriptomes and genomes, we demonstrated significant copy number variations within the repertoire of PUFA biosynthesis genes among ecologically diverging copepod orders. Following two presumable horizontal gene transfer (HGT) events from an unknown donor to a common copepod ancestor, methyl-end desaturases and front-end desaturases, key enzymes in PUFA biosynthesis, were retained in Cyclopoida, Harpacticoida and Siphonostomatoida but lost in most Calanoida (except for certain *Calanus* and *Neocalanus* species which still have one front-end desaturase). All orders show strong expansion of the fatty acyl elongase subfamily elovl1/7, and while total elongase copy number did not differ among orders, the expression of these genes was higher than average in Harpacticoida and lower in Calanoida. All desaturase and elongase gene families exhibited non-clustered distribution in the assessed genomes, and positive selection on specific codons following HGT and duplication events. Overall, the unique but varying PUFA biosynthesis capacity of copepods enables maintenance of high PUFA levels even under dietary constraints in certain species and further ensures PUFA provisioning to higher trophic levels. These findings have important implications for nutrient and energy flow in changing environments.