Designing Lightweight 3D-Printable Bioinspired Structures for Enhanced Compression and Energy Absorption Properties	
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Abstract: Recent progress in additive manufacturing, also known as 3D printing, has offered several benefits, including high geometrical freedom and the ability to create bioinspired structures with intricate details. Mantis shrimp can scrape the shells of prey molluscs with its hammer-shaped stick, while beetles have highly adapted forewings that are lightweight, tough, and strong. This paper introduces a design approach for bioinspired lattice structures by mimicking the internal microstructures of a beetle's forewing, a mantis shrimp's shell, and a mantis shrimp's dactyl club, with improved mechanical properties. Finite element analysis (FEA) and experimental characterisation of 3D printed polylactic acid (PLA) samples with bioinspired structures were performed to determine their compression and impact properties. The results showed that designing a bioinspired lattice with unit cells parallel to the load direction improved quasi-static compressive performance, among other lattice structures. The gyroid honeycomb lattice design of the insect forewings and mantis shrimp dactyl clubs outperformed the gyroid honeycomb design of the mantis shrimp shell, with improvements in ultimate mechanical strength, Young's modulus, and drop weight impact. On the other hand, hybrid designs created by merging two different designs reduced bending deformation to control collapse during drop weight impact. This work holds promise for the development of bioinspired lattices employing designs with improved properties, which can have potential implications for lightweight high-performance applications.

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