

Integrated Research of Coastal Development Effects on *Tachypleus tridentatus* and the Estimation of Its Suitable Spawning Habitat in Tsuyazaki Cove, Japan

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<https://hdl.handle.net/2324/7182424>

出版情報 : Kyushu University, 2023, 博士 (工学) , 課程博士
バージョン :
権利関係 :



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論 文 名 : Integrated Research of Coastal Development Effects on *Tachypleus tridentatus* and the Estimation of Its Suitable Spawning Habitat in Tsuyazaki Cove, Japan
(津屋崎入江における沿岸開発がカブトガニ *Tachypleus tridentatus* に及ぼす影響と産卵適地の推定に関する統合的研究)

区 分 : 甲

論 文 内 容 の 要 旨

Horseshoe crabs have significant biological and medical importance. They serve as indicators of the ecological health of coastal environments and play a pivotal role in medical testing due to the essential nature of their blood. In Asia, their survival is threatened by the loss of their habitats due to coastal development and the exploitation of horseshoe crabs for economic and medical purposes. Despite these escalating demands, a critical conservation challenge lacks essential baseline data on horseshoe crabs' populations, distribution, and habitat status.

The critically endangered horseshoe crab species, *Tachypleus tridentatus*, occurs in Japan. The species is distributed in northern Kyushu and the Seto Inland Sea, and has experienced a significant population decline, primarily related to habitat alterations from human activities like landfilling and associated coastal development. The spawning behaviour of *T. tridentatus* is closely tied to specific sandy beach environments within inner bays. The physical characteristics of these spawning grounds, as studied in Asian regions, include, for example, nesting zone, nest temperature, water content, and sedimentary properties. There is increasing urgency to investigate the causal relationships between coastal development and the declining *T. tridentatus* populations, as well as to create scientific models to assess these effects on their spawning habitats. However, the previous research lacks a comprehensive analysis linking spawning data and physical parameters to evaluate the impact of coastal development on the *T. tridentatus* spawning habitat. Also, the development of scientific models to elaborate these causal relationships remains largely unexplored. Consequently, despite the alarming threat of global extinction of *T. tridentatus* populations, scientific research has not comprehensively elucidated the underlying factors responsible for this decline.

This research aims to explore these unexplored scientific aspects and offer general conclusions applicable to conserving *T. tridentatus* spawning grounds. Tsuyazaki Cove in Fukuoka, renowned as a core site for *T. tridentatus* studies in Japan, was chosen for its suitability in achieving these aims. The research objectives include a long-term investigation into the historical impacts of coastal development on spawning grounds, as well as integrating biological data with pertinent physical parameters to estimate these effects on the spawning sites. This comprehensive research study is the first published quantitative evidence of the potential impact of coastal development on *T. tridentatus* spawning habitats and the subsequent population decline.

Chapter 1 introduces the research background, previous studies and their problems, research aims and objectives, proposed methodology and methods, study site description, and overall dissertation structure.

Chapter 2 sets the stage for subsequent studies by identifying the need to explore specific elements contributing to the decline. It focused on historical spawning habitat changes through aerial photograph analysis, interviews, and field monitoring of spawning numbers. The findings attributed the decrease of *T. tridentatus* to the cove entrance modification, leading to disrupted sediment transport routes, which caused the degradation of spawning habitats in the area.

Chapter 3 narrows its target to the spawning site selection and nesting patterns of *T. tridentatus*, unveiling modified beach shapes attributed to landfills and corresponding changes in nesting behaviours. The study revealed that some eggs were laid in lower intertidal zones, previously considered "unsuitable" for spawning. This shift in egg deposition occurred when the original beach shape had been altered due to coastal development. The study underscored the significance of preserving original beach shapes to uphold the presence of appropriate spawning habitats.

In Chapter 4, a field experiment was conducted to test the hypothesis formulated based on the findings in Chapter 3. Specifically, the experiment sought to ascertain the survival rates of eggs deposited within a previously considered "unsuitable" zone. It was achieved by translocating the eggs to various intertidal elevations. The study indicated the critical role of beach elevation in egg survival. The mid intertidal zone was the most suitable, influenced by appropriate air exposure and water content. In contrast, eggs within the low intertidal zone exhibited the least survival rate, suggesting that the area where the original beach morphology underwent significant modifications due to coastal development was judged "unsuitable" for optimal egg development.

Chapter 5 leverages the knowledge gained from previous chapters to understand the species' spawning habitat requirements comprehensively and proposes a tangible approach to conservation efforts. The study identifies the specific spawning conditions and areas where *T. tridentatus* can thrive, making it a logical extension of the investigations into spawning site selection (Chapter 3) and egg survival (Chapter 4). Given the absence of scientifically established suitable spawning habitats for *T. tridentatus* in previous studies, in Chapter 5, scientific models based on naturally spawned nest/egg occurrence data and their physical parameters were employed to quantify the extent of remaining suitable spawning habitats in the study site. The remaining suitable spawning areas were also spatially mapped based on the estimated results. The study highlighted that beach elevation was the predominant determinant for estimating spawning habitat suitability. Furthermore, it emphasised that within the study site, the persisting suitable areas measure a mere 476m², suggesting that coastal development has engendered the fragmentation of the spawning beaches.

Chapter 6 serves as the conclusion and offers recommendations for conserving the local population. Conservation strategies are proposed, including protecting remaining spawning grounds, beach nourishment, restoring sand supply, and implementing legal regulations. Finally, further research, which falls beyond the scope of this dissertation, is recommended.

This systematic approach ensures that each study builds upon the previous one, contributing to a comprehensive understanding of the species' spawning habitat and ultimately culminating in specific strategies for conservation. The published research studies identify the causal links between coastal development and the declining *T. tridentatus* populations in the area, underscoring the importance of habitat conservation and the restoration of suitable spawning sites for this critically endangered species. The insights from these collective studies can be further applied to *T. tridentatus* populations facing global extinction.