中文摘要

本研究主要目的為結合寄主–致病菌關係之非線性流行病學動態模式與生命階段矩陣族群模式以評估文蛤 (*Meretrix lusoria*) 族群暴露受汞緊迫之文蛤病毒之易感性。其中並以動態能量支出 (dynamic energy budget) 模式結合生物能量為基礎之成長模式以三種毒性作用模態 (mode of action, MOA) 描述汞毒性抑制下文蛤成長機率。再者應用損害評估模式 (damage assessment model) 為基礎之 Hill 模式探討內部濃度和死亡率之關係以評估存活機率。並以冪函數 (power function) 描述繁殖率與重量之間的關係，以評估汞緊迫下繁殖抑制效應。上述之成長、存活及繁殖率可評估自然和緊迫環境下之生命參數 (vital rate)，進一步評估族群成長率和族群動態。本研究以疾病動態之易感–感染–死亡 (susceptible–infectious–mortality, SIM) 模式描述不同緊迫影響之疾病傳輸率 (transmission rate) 和致死率 (mortality rate)，推估疾病成功感染之基本再生數 (basic reproductive number, R_0)。本文將感染情形區分為感染疾病後暴露於汞緊迫環境和暴露於汞緊迫環境隨即感染疾病二者，以探討文蛤之易感性。本研究結果顯示，汞濃度小於 10 μg L^{-1} 時文蛤族群成長率大於 1，若暴露於汞濃度大於 30 μg L^{-1} 時族群將會減少。由此可推估一年後族群數目減少一半時之效應濃度 (effect concentration causing 50 % reduction, *ER*50) 為 12.07 μg L^{-1}，此減少之效應濃度可預測且控制族群的收成量。本研究針對不同生命階段之疾病傳輸過程預測感染疾病後暴露於汞緊迫環境和暴露於汞緊迫環境隨即感染疾病下的二十天內族群分別減少 60 % 及 80 %。若疾病傳輸率分別減少為 0.4 及 0.2 倍時，將能有效的管理且控制疾病爆發。本研究提供一簡單且具理論基礎之模式以評估文蛤暴露於受汞緊迫之文蛤病毒之易感性，亦進一步建議養殖文蛤數目若小於 400 ind m^{-2} 可有效防止疾病爆發。本模式可適用於其他養殖生物暴露於緊迫金屬之疾病傳輸，並提供養殖業者有效控制策略。

關鍵字：文蛤；汞；族群動態；矩陣族群模式；疾病傳輸；易感性

Abstract

The purpose of this thesis is to assess the susceptibility of hard clam (*Meretrix lusoria*) populations exposed to mercury (Hg)-stressed birnavirus by integrating nonlinear epidemiological dynamics of host–pathogen relationships into a stage-structured matrix population model. Dynamic energy budget (DEB_{tox}) theory links bioenergetics-based growth model to enhance toxicity assessments of Hg and describe the growth probability of toxicity inhibition distinguish from three modes of toxic action (MOA). For estimating survival probability, this study employs damage assessment model (DAM)-based Hill model to assess the relationship between internal burden concentration and mortality. Fecundity rate is related to weight-varied which is calculated from power function. Vital rate can be evaluated among growth, survival, and fecundity rate, population growth rate (λ) and population dynamics of hard clam exposed to Hg-stressed can be further estimated. Moreover, stressor-specific transmission rate, mortality rate from disease-induced susceptible-infectious-mortality (SIM) model are estimated to evaluate basic reproductive number (R_0) which is defined as the average number of secondary cases generated by one primary infected case. Two kinds of disease challenge experiments of virus + Hg and Hg + virus are considered to assess the susceptibility of hard clam exposed to Hg-stressed birnavirus. The results show $\lambda > 1$ within 10 μg Hg L^{-1}, however, hard clam populations will decreased when exposed to > 30 μg Hg L^{-1}. The effect concentration causing 50 % reduction (*ER*50) is estimated to be 12.07 μg L^{-1} after a 1-year simulation, by which hard clam populations harvest controlling can be pre-analyzed. The results considering the processes of stage-specific disease transmission also indicate that clam populations will decreased to 60 % for virus + 5 μg L^{-1} and 80 % for 5 μg L^{-1}+ virus within 20 days. On the other hand, when transmission rates reduced to 0.4 and 0.2 fold for virus + 5 μg L^{-1} and 5 μg L^{-1}+ virus, respectively, the disease outbreak can be totally contained. Moreover, this study presents a simple and mechanistic-based model to effectively assess the susceptibility of hard clam exposed to Hg-stressed birnavirus. The results indicate that hard clam populations less than 400 ind m^{-2} can be allowed to control outbreak. It is confident that the model can be easily adapted for other aquaculture species to assess chemical-stressed pathogen.

Keywords: Hard clam; *Meretrix lusoria*; Mercury; Population dynamic; Matrix population model; Disease transmission; Susceptibility