Bhattacharyya, S.; **Bhattacharya, D. K.**

An improved integrated pest management model under 2 control parameters (sterile male and pesticide). (English) Zbl 1120.92042

Math. Biosci. 209, No. 1, 256-281 (2007).

Summary: The object of the present paper is to study an integrated pest management (IPM) problem in an agro-ecosystem (paddy-fish culture) through mathematical modeling and analysis, where release of sterile males and spraying of pesticide have been used as control measures for the pest population. Using optimal analysis of the model, we have shown that restricted and proper use of control measures might enhance the crop production of the system in an economically viable way. The paper also considers the vulnerability of the underlined ecosystem due to the effect of temperature on the pest growth. Using Lyapunov-like functions, we have found out a suitable range of temperature, where this IPM strategy remains effective. Some important remarks have finally been made on the basis of numerical simulations.

MSC:

92D40 Ecology
93C95 Application models in control theory
49N90 Applications of optimal control and differential games

Keywords:

sterile males; vulnerability of the system; singular control; Pontryagin's maximum principle

Software:

WinPP; XPPAUT

Full Text: DOI

References:

[1] T.C. Banerjee, Population growth, in: D.K. Basu, A. Malik, A.R. Ghosh, (Eds.), Environment: issues and challenges, Academic Staff College, University of Burdwan, (sponsored by University of Grant Commission), India, 1999.

[2] Baumhover, A.H.; Graham, A.J.; Bitter, B.A.; Hopkins, W.D.; Dudley, F.H.; Bushland, R.C., Screw-worm control through release of sterilized flies, J. econ. entomol., 48, 462, (1955)

[3] Bhattacharyya, S.; Bhattacharya, D.K., A new approach to pest management problem, J. biol. syst., 13, 2, 117, (2005) · Zbl 1070.92047

[4] P.K. Bhattacharyya, S.R. Das, Aspects and appraisals of the Sundarbans Mangals, in: D.K. Basu, A. Malik, A.R. Ghosh (Eds.), Environment: issues and challenges, Academic Staff College, University of Burdwan, (sponsored by University of Grant Commission), India, 1999.

[5] Bhattacharya, D.K.; Karan, S., Pest management of two non-interacting pests in the presence of a common predator, J. appl. math. comput., 13, 1-2, 301, (2003) · Zbl 1047.34033

[6] R. Cavalloro, Statistical and mathematical methods in population dynamics and pest control, in: Proceedings of a meeting of the EC Experts' Group/Parma, 26-28 October, 1983, Balkema, Rotterdam/Boston, 1984.

[7] Costello, W.; Taylor, H., Mathematical models of the sterile male technique of insect control: lecture notes in biomath.-35, (1975), Springer New york, pp. 318

[8] Chaudhury, K.S., Bioeconomic study of a multi-species pest subjected to pesticide internal report, (1986), ICTP Trieste, Italy

[9] Dietz, K., The effect of immigration on genetic control, Theor. popul. biol., 9, 58, (1976) · Zbl 0335.92015

[10] G.B. Ermentrout, WINPP(XPPAUT) 3.0, the differential equation tool, <http://info.pitt.edu/phase/>.

[11] Freedman, H.I., Deterministic mathematical models in population ecology, (1980), Marcel Dekker New York/Basel · Zbl 0448.92023

[12] Goh, B.S., Management and analysis of biological populations, (1980), Elsevier scientific publishing company Amsterdam, Oxford, NY · Zbl 0453.92015

[13] Hill, S.D., Agricultural insect pest of the tropics and their control, (1993), Cambridge University New York, Bessel

[14] Holling, C.S., The functional response of predator to prey density and its role in mimicry and population regulation, Mem.

entomol. soc. can., 45, 5, (1965)

[15] D.J. Horn, Ecological Approaches to pest management, Guilford, NY, 1988, 285pp.

[16] G.J. Hallman, D.L. Denlinger, Temperature sensitivity and integrated pest management, An article, (<http://pestdata.ncsu.edu/ipmtext/>).

[17] Kaspi, R.; Parrella, M., The potential of the sterile insect technique as one of the strategies for control of the \textit{liriomyza trifolii} (diptera: agromyzidae) infesting greenhouse crops, J. IOBC/wprs bull., 25, 123, (2002)

[18] Knipling, E.F., Possibilities of insect control or eradication through the use of sexually sterile males, J. econ. entomol., 45, 459, (1955)

[19] Midlen, A.; Redding, T.A., Environmental management for aquaculture, (1998), Chapman & Hall London

[20] Nagumo, N., Uber die lage der integralkurven gewonlicher differantialgleichungen, Proc. phy. math. soc, Japan, 24, 551, (1942) · Zbl 0061.17204

[21] Odum, E.P., Fundamentals of ecology, (1971), W.B. Saunders Company USA

[22] Perkins, J.H., Insects, experts and the insecticide crisis, (1982), Springer Berlin

[23] Plant, E.R.; Mangel, M., Modelling and simulation in agricultural pest management, SIAM rev., 36, 2, (1987) · Zbl 0612.92014

[24] Prout, T., The joint effect of release of sterile males and immigration of fertilized females on a density regulated population, J. popul. bio., 13, 40, (1978)

[25] Turchin, P., Complex population dynamics: A theoretical/empirical synthesis, (2003), Princeton University Princeton, NJ · Zbl 1062.92077

[26] A.M. Van der Vloedt, W. Klassen, The development and application of the sterile insect technique (SIT) for New World screw-worm eradication, An Article, <{http://www.fao.org/ag/AGa/AGAP/FRG/FEEDback/War/u4220b/u4220b0j.htm}/> theoretical basis of the sterile insect technique.

[27] Watt, K.E.F., Ecology and resource management, (1968), Mc. Graw-Hill New York

[28] Wyatt, I.J.; Brown, S.J., The influences of light intensity, daylength and temperature on increase rates of four glasshouse aphids, J. appl. ecol., 14, 391, (1977)