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'Economic Injury Level' and preventive pest control

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Abstract

Although the 'Economic Injury Level' (EIL) concept belongs to the keystones of IPM theory, its applicability to all pest problems is believed not to be universal. Current IPM theory claims that the EIL concept is of limited use (i) in situations where an injury-damage function cannot be established, (ii) if pest monitoring is impossible or EIL is very low, and (iii) with preventive measures of pests and pathogens. In this work, I argue that the two latter points may not be true. First, within IPM all types of chemical treatment, including preventive ones, should be economically justified via calculation of EIL, based on the comparison of the cost of preventive and responsive control measures and the cost of the forecasted/expected damage. The 'expected' damage should be based on long-term (historical) damage records, manipulative experiments, risk assessment and biomathematical modelling of the evaluated pathosystem. Second, the absence of EIL in 'preventively controlled pests' hampers completion of the consistent Stern–Pedigo's classification of pest organisms according to mutual position of EIL and General Equilibrium Position (GEP) or Stationary Distribution of Population Densities (SDPD).

1 Introduction

The concepts of 'Economic Injury Level' and 'Economic Threshold' are considered keystones of the present Integrated Pest Management (IPM) (Stern et al., 1959; Pedigo, 1991; Stejskal, 2001; Stejskal, 2002). Originally Stern et al. (1959) defined the 'Economic Injury Level' (EIL) as the lowest population density that will cause enough economic damage to justify the cost of artificial control measures. Later, Southwood and Norton (1973) and Ramirez and Saunders (1999) redefined EIL as the pest density at which the cost of additional control equals the economic loss prevented by implementing the control measure. Clearly, the EIL provides, as a decision-making tool, information whether the cost of damage caused by pest organisms justifies the cost of artificial control measures (Stern et al., 1959; Mumford and Knight, 1997). The American Phytopathological Society (Nutter et al., 1993) recommends replacing EIL by an equivalent 'Economic Damage Level' (EDL) since '*decision thresholds are based on both injury and price*'. In this text, I use the more popular term EIL accompanied by the more precise term EDL in brackets to avoid confusion. 'Economic Threshold' (ET) (= Action Threshold, AT) is defined as a critical pest population size when management action should be taken to prevent reaching EIL (EDL) and is an operational criterion instructing when to apply the control measure.

Although the above threshold concepts dominate both IPM theory and practice, it is generally accepted that they are not universally applicable to all pest problems. For example, it is coined (Horn, 1988; Pedigo et al., 1986; Pedigo, 1991) that in the case of aesthetic or medical pests it is hard or impossible to rigorously establish the injury-damage function and to estimate the cost of damage to human health. It is believed that the EIL concept is redundant where EIL is very low and/or pest monitoring is difficult, expensive or completely missing. Binns et al. (2000) and Pedigo (1991) claim that the EIL (EDL) concept is irrelevant or of limited use with preventive measures of pests and pathogens; e.g. Pedigo (1991) states '*Management of tactics of pathogens are more often preventive, not therapeutic; therefore determining whether or not a pathogen population is at the EIL after infection may not be of significant value if the only management options available must be applied before infection.*' Nevertheless, I think this may not always be true. In addition, the latter statements are in contradiction with the original definition and concept of EIL as introduced by Stern et al. (1959).

Therefore, the aim of this terminological note is to show that it makes sense to establish the EIL (EDL) even for those pest organisms that current management requires the preventive control.

2 The justification of EIL (EDL) for preventively controlled pest organisms

I propose three arguments justifying the utility to establish EIL (EDL) for preventively controlled pest organisms:

2.1 EIL (EDL) and the economic justification of preventive pesticide treatments

Mumford (1982) found that the 'pest status' of many crop-associated organisms, estimated intuitively by farmers, is false or seriously overrated. Also Heong and Escalada (1999) reported that many insecticide sprays are targeted at leaf feeders (e.g. the moth *Cnaphalocrocis medinalis* Guenee) that cause highly visible damage symptoms but negligible yield loss. These works document that many applications of pesticides are too high or completely redundant. Expressed in Stearn's and Pedigo's IPM terminology, the populations of many pests are controlled, although their general equilibrium position is far below EIL.

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The original goal of the development of EIL (EDL) theory was to reduce pesticide use by enabling non-intuitive (i.e. objective-numerical) evaluation of the pest status. In cases where population monitoring of pests is impossible, EIL is very low, curative measures do not exist, act very slowly (e.g. cooling of stored grain to prevent pest infestation; SUBRAMANYAM and HAGSTRUM, 2000) or are inefficient, then ET usually equals zero. Nevertheless, the zero ET, associated with the preventive control, does not imply redundancy of the establishment of EIL (EDL) as claimed by PEDIGO (1991) and others. The above-cited EIL definition by STEARNS et al. (1959) clearly says that the ultimate goal of the EIL concept was proposed to enable the economical analysis and justification of chemical control, not the construction of economic (ET) or action (AT) thresholds. Within the cost-benefit IPM analysis, the cost of all integrated control measures should be taken into account. However, currently the economy of the preventive control lies illogically beyond the focus of EIL (EDL) analysis. I am convinced that the original EIL definition by STERN et al. (1959) implies that even the use of solely preventive strategy (ET = 0) should be economically justified via EIL (EDL). In that case, EIL (EDL) includes a comparison of the cost of preventive measures and the cost of the 'forecasted', 'expected' or, at least, 'usual' yield damage for given pests, crop and geographical area. The 'expected/forecasted' damage should be based on the long-term (historical) damage-records, manipulative experiments and biomathematical modelling of the evaluated pathosystem. The 'risk' (probability) of the damage-event occurring should also be taken into account. I think that the establishment of exact EILs (EDLs) of 'preventively controlled' pest organisms may help to re-evaluate their pest status (MUMFORD, 1982) and has potential to decrease the use of some preventive pesticide measures (STEJSKAL and LUKAS, 2002).

2.2 Paradox of a 'preventive/zero-ET' when used as a time parameter

It may also seem that the 'preventive/zero-ET' is unproblematic or uninteresting from the point of view of IPM theory. PEDIGO (1991) insists that although usually expressed in insect numbers, the ET is really a time parameter, with pest numbers being used only as an index for when to implement management. The fact that Pedigo's ET is actually a 'date of the treatment' creates an interesting paradox for zero-ET. Although there is only a single-number for critical pest population size (i.e. ET = 0), the preventive treatment may be realised at various dates, which, however, differ in their biological effects and technical and/or economical suitability. Thus, even the establishment of the 'preventive' single-number-ET may be complex; not with regard to pest numbers but solely to the proper timing.

2.3 EIL (EDL), 'General Equilibrium Position' (GEP) and the classification of pests

STERN et al. (1959) and PEDIGO (1991) developed a general prediction for the control of various pests, classified according to a mutual position in GEP and EIL (EDL) into the following main categories: (i) 'sub-economic pests' (EIL/EDL/ always < GEP), (ii) 'occasional pests' (EIL/EDL/ sometimes > GEP), and (iii) 'perennial or severe pests' (EIL /EDL/often or always > GEP) (Stern- Pedigo's pest classification). However, the absence of EILs (EDLs) in 'preventively-controlled' pests prevents the establishment of their 'pest-status' and the completion of the consistent comparative Stern- Pedigo's classification for all agricultural pest organisms.

Discussing EIL (EDL), GEP and Stern- Pedigo's pest classification, I would like to make a final terminological suggestion. Recently, HANSKI (1999) stressed that the term 'population equilibrium' has been a source of confusion, as most populations are characterised by more or less fluctuating population size rather than a constant size, even if there is no long-term increasing or decreasing trend. He advised to term such a population state a 'Stationary Distribution of Population Densities' (SDPD) (TURCHIN, 1995). Therefore. IPM theory and Stern- Pedigo's pest classification should be followed by ecologists and the term GEP should be replaced by the term SDPD.

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