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ECONOMIC AND AESTHETIC INJURY LEVELS AND THRESHOLDS FOR INSECT PESTS OF ORNAMENTAL PLANTS

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ABSTRACT

This article reviews decision-making considerations that apply to the management of insect pests of ornamental plants. In particular we estimate a modified Economic Injury Level (EIL) for the bagworm, *Thyridopteryx ephemeraeformis* (Haworth), attacking American arborvitae, *Thuja occidentalis* under retail nursery conditions. Under these circumstances, the EIL was found to be only about four first instar larvae per 4 ft tree. This confirms earlier suppositions concerning the low tolerance for pests causing aesthetic injury. In addition, we briefly examine the concepts of Aesthetic Injury Levels

(AIL) and Aesthetic Thresholds and illustrate how these may be estimated for pests causing aesthetic injury.

RESUMEN

En este artículo se revisan los factores utilizados en el proceso de toma de decisiones para el manejo de insectos consideralos como plagas de plantas ornamentales. En particular, hemos estimado un nivel de daño económico para el gusano cargacartucho *Thyridopteryx ephemeraefozmis* (Haworth), el cual ataca a *Thuja occidentalis* en planteles de plantas ornamentales. Bajo estas circunstancias, se determinó un nivel de daño económico de alrededor de 4 larvas en el primer estadio por cada 4 pies de árbol. Con esto, se confirman suposiciones anteriores relacionadas a la baja tolerancia de plagas causantes de daños estéticos. En adición, se examina brevemente el concepto de niveles de daño estético y umbrales estéticos y se ilustra como éstos pueden ser estimados en plagas que causan daños estéticos.

The last decade has seen a proliferation of integrated pest management programs in residential environments (Olkowski et al. 1976, 1978, Davidson et al. 1981, Hellman et al. 1982, Short et al. 1982, Holmes & Davidson 1984, Raupp & Noland 1984, Smith & Raupp 1986, Cornell & Davidson 1987). One important limitation to several of these programs was the lack of rigorously defined decision-making rules similar to the economic injury level that has grained wide use in agronomic systems. Potter (1986) and Pedigo et al. (1986) have identified the lack of decision-making guidelines as a fundamental limitation of urban pest management programs.

One decision-maing approach that has gained widespread utility in agronomic sectors is the use of economic injury levels (EIL). Stern et al. (1959) were the first to introduce this term. They defined it as the lowest population level that causes economic damage. Recently, Pedigo et al. (1986) presented a standardized model useful in determining economic injury levels. Using this approach the EIL is determined by the cost of management per unit of production (C), the market value per unit of produce (V), the injury units per insect for each unit of produce (I), and the damage per unit of injury (D). The EIL is expressed in injury equivalents per unit of production and is related to these parameters in the following way: EIL = C/VID.

This article serves a synopsis of a more thorough review published elsewhere (Raupp et al. 1988). Detailed descriptions of methods, results, and their interpretation are found in this earlier work. Here we briefly examine decision-making considerations as they relate to pests of woody ornamental plants. To demonstrate how decision-making rules can be formulated for pests causing aesthetic damage, we selected a common ornamental plant American arborvitae (*Thuja occidentalis*) and an associated insect pest the bagworm (*Thyridopteryx ephemeraeformis* (Haworth).

We used the model of Pedigo et al. (1986) to estimate an EIL for a defoliator, the bagworm, on an ornamental shrub, American arborvitae. To determine the parameters used to calculate the EIL, we adopted the perspective of a retail nurseryman who manages ornamental plants for economic gain.

Using the estimates described in Raupp et al. (1988) and the methodology of Pedigo et al. (1986), the EIL for this system was about 4 bagworm larvae/4 ft tree. From an operational standpoint, this extremely low EIL has several important implications. Published accounts of bagworm life histories in conjunction with our findings indicate that a single female bagworm has the potential to create an infestation exceeding the EIL of the retail nurseryman (Barrows 1974, Horn & Sheppard 1979). This finding highlights the need for effective monitoring approaches that can facilitate pest detection

and intervention prior to injury. Furthermore, this finding confirms the supposition made by several authors regarding the extremely low tolerance of people for aesthetic injury (National Research Council 1980, Larew et al. 1984, Zungoli & Robinson 1984, Sadof & Raupp 1987, Raupp et al. 1988).

The plant retailer is but one decision-maker with regard to managing pests of ornamental plants. The vast majority of woody ornamental plants are components of managed landscapes. For pest managers such as homeowners, economic factors may not be the primary ones that affect management decisions (Potter 1986, Pedigo et al. 1986, Raupp et al. 1988). It was for these non-economic situations that Olkowski (1974) suggested the use of an Aesthetic Injury Level (AIL) to form the basis for management decisions. The AIL was considered to be the lowest level of a pest that caused aesthetic injury (Olkowski 1974). This concept proved extremely valuable for making management decisions for a variety of insect pests attacking street trees in California (Olkowski et al. 1978).

Since the AIL was first conceived, several other works have contributed to our understanding of decision-making as it relates to pests causing aesthetic injury. Buhyoff & Leuschner (1978) provided one of the first examples of the relationship between plant injury and aesthetic damage. They photographed forested landscapes that had been injured by the southern pine beetle. These photographs were shown to different groups of subjects that evaluated their landscape utility. The visual preference of those surveyed declined dramatically between injury levels of 0 and 10% of the landscape damaged. At greater levels of injury, little decline in disutility was noted. Based on their findings, Buhyoff & Leuschner (1978) suggested that management efforts for southern pine beetle be directed at preventing new outbreaks.

Koehler & Moore (1983) were the first to quantify the relationship between insect abundance and an indicator of aesthetic quality. For the cypress tip moth, *Argyresthia cupressella* Walsingham, they demonstrated that the unsightliness of a plant increased as a simple linear function of tipminer abundance. Larew et al. (1984) determined a similar relationship for serpentine leafminer injury on chrysanthemums. In this case leafminer injury was directly related to the marketability of the plant.

Parrella & Jones (1987) also emphasized the importance of aesthetic considerations in managing pests of greenhouse crops. Cut flowers, such as chrysanthemums and gerbera, sustain considerable injury from leafminers. However, the injury often occurs on plant parts that are not marketed. Parrella & Jones (1987) suggested that a modified AIL be adopted for the floricultural industry. This AIL would permit damage to nonmarketed parts thereby reducing unnecessary pesticide use. Reductions in the number of of pesticide applications could greatly facilitate biological control in greenhouses.

The ideas formulated in these earlier works prove useful in generating decision-making rules for the system involving arborvitae and bagworms. During the survey at retail nurseries, we asked customers which plant or plants showed damage and which plant or plants had enough damage to warrant control. The first question was used to estimate the bagworm density that caused aesthetic damage. We regard this density to be analogous to the EIL defined by Stern et al. (1959). However, one difference is noteworthy. In the case of the EIL, the density of importance is the lowest one causing economic injury. In the case of the AIL, we were interested in establishing a density that would be perceived as damaging by the average individual. The level of injury perceived as damaging by half of those surveyed corresponded to about 5% of the leaf area missing or discolored. This estimate translates into about 6 first instar bagworm larvae per 4 ft tree. For this sytem the EIL for the retail nurseryman and AIL for the customer are quite similar.

Stern et al. (1959) defined the economic threshold as the population density at which control is determined to prevent a population from reaching an economic level. The

relationship between plant injury and the perceptions of retail nursery customers can be used to identify a similar decision-making rule based on aesthetic considerations. By asking customers to identify which plant or plants had enough damage to warrant control, we determined that half would initiate control when about 6% of the leaf area was missing or discolored. The bagworm density causing this level of injury is about nine per 4 ft tree. This density is functionally analagous to the ET defined by Stern et al. (1959) and can be considered an aesthetic threshold (AT) for this system.

In some cases the mere presence of an offending organism may be sufficient to cause injury and initiate a management decision. Wood et al. (1981) and Zungoli & Robinson (1984) surveyed occupants of public housing units in three mid-Atlantic cities. Their data indicate that as few as two cockroaches observed in an afternoon were perceived as creating a problem by half of those surveyed. Furthermore, one to two cockroaches seen in a household in a day were sufficient to warrant a control action by half of those surveyed. These residents had well-defined perceptions concerning when coackroaches were creating a problem and when they required control.

In summary, it is our hope that this review will prove useful in formulating decision-making rules for pests causing aesthetic injury. Perceptions of those influencing management decisions must be quantified when the utility of the managed resource is based on its appearance. When economic gain is important, as is the case of nursery and greenhouse crops, economic injury levels and thresholds will form the basis of management decisions. However, in many systems such as those involving established landscapes and turf, aesthetic consideration may overshadow economic ones. Aesthetic injury levels and thresholds may be the appropriate basis for management decisions in these systems.

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