NBR RECRUITMENT CURVE EXPERIMENT METADATA:

Varley et al. (1973) develop how recruitment curves (plot of current generation's density, N_t, vs. next generation's density, $N_{t=1}$) can be used to describe insect population dynamics. Southwood and Comins (1976) and May (1976) demonstrate that the recruitment curve becomes bimodal, rather than unimodal, when the insect's predator exhibits a Type III functional-numerical response. If the observed hatch density is on the first "wave" of the recruitment curve then predation is limiting or if it is on the second peak of the recruitment curve then food is limiting.

A. COLOR –
   1) <u>Gray</u> = year of study
   2) <u>Blue</u> = HILL site (UTM 706453 EAST 5249980 NORTH)
   3) <u>Rose</u> = TRIANGLE site (UTM 713570 EAST 5248100 NORTH)

B. YEAR –
   1) <u>Study</u>. The study began in 1992 at HILL site and in 1994 at TRIANGLE site and has continued every year. The dominant grasshopper species at both sites was *Melanoplus sanguinipes*, comprising respectively 70% and 50% of individuals at the two sites, and more than 80% of grasshopper biomass.
   2) <u>Experiment</u>. At the HILL from 1992 – 1993, twelve 9 m^2 enclosures (3 m X 3 m X 0.5 m) constructed of nylon insect screen, supported by three aluminum frames, and attached to plastic garden edge buried along the perimeter constituted the experiment. At both sites from 1994, the experiment employed fifteen enclosures. Each site also had three 9 m^2 control areas (3 m X 3 m enclosed by plastic garden edging). Each enclosure and control contained 8 0.1 m^2 rings placed equidistant around the perimeter.
   3) <u>Measurements.</u> Twice in one day (late-morning and mid-afternoon) every week from mid-June through mid-September, two observers moved from ring to ring, while a third individual tapped inside the ring with a stick (through a sleeve built into each enclosure) and counted the grasshoppers that emerged or could be seen sitting in the ring. The average of the two counts for a week divided by 0.8 provided an estimate of grasshopper density (#/m^2). These weekly density estimates constituted the basic data.
   4) <u>Calibration</u>. From studies conducted in 1992, all grasshoppers were removed from a set of enclosures and restocked with known numbers of *M. sanguinipes*. Ring counts were then conducted by individuals unaware of the number stocked in each enclosure. The correlation between the estimated and actual densities was very high (r = 0.96, N = 12, P < 0.0001); furthermore, the intercept was not different from zero and the slope was not different from 1).
   4) <u>Stocking</u>. The control areas provided an estimate of grasshoppers hatching in the field at the site. Initial hatchling density was assessed in late-June or early-July as the average of the highest values observed in the control area for the site. Initial hatchling density for each enclosure at a site was its highest observed value. Each enclosure at a site was assigned a grasshopper density treatment-level (25%, 50%, 100%, 125%, or 150% of field, i.e. control, initial density) so that each level was replicated 3 times. Assignment of the treatment level was a random selection among the enclosures with initial density levels less than the treatment-level (i.e., it is too difficult to remove individuals from enclosures to achieve a given treatment level). The needed number of grasshoppers to attain the

treatment-level was added to an enclosure using field caught individuals of all available developmental stages at the time. Only *M. sanguinipes* were used.

5) Simulated predation. Each week after stocking, grasshoppers were removed from each enclosure to simulate predation. The number removed was based upon that week's density estimate for the enclosure and a previously determined relationship between grasshopper density and weekly predation rates in the field (Belovsky et al. 1990, Belovsky & Slade 1993).

C. WITHIN EACH SITE.

1) Initial Density (N_t) and S.D. = stocking density in the current year + Σ (positive values of $D_{w+1} - D_w$) in the current year. Stocking density is defined above in B.4. The summation reflects any hatching of eggs after the stocking of an enclosure. Similar values (C.V. = $\pm 10\%$) were averaged, where N is the number of enclosures combined.

2) Predation = proportion of population experimentally removed by simulated predation and Type III functional/numerical response.

3) Next Year's Density (N_{t+1}) and S.D. = initial hatching density in the next year + Σ (positive values of $D_{w+1} - D_w$) in the next year. Initial density is defined above in B.4. The summation reflects any hatching of eggs after the stocking of an enclosure.

4) Statistics. The following values are provided:

    a. unimodal parabolic fit = $N_{t+1} = a + bN_t - cN_t$, where a, b and c are constants.

    b. bimodal parabolic fit = recruitment curve composed of two "wave-like" functions, which is assessed using a statistical test based on nonlinear regression and "traveling wave" functions (Jeffrey 1995):

        Two waves ---

$$N_{t+1} = \begin{cases} aN_t - bN_t^2 & \text{,where } N_t \leq \text{break} \\ c + dN_t - eN_t^2 & \text{, where } N_t \geq \text{break} \end{cases}$$

        where a, b, c, d, e and the break are constants.

        Using the unimodal and bimodal functions, the best fit was determined using the AIC index (Burnham and Anderson 2002) to control for the different numbers of parameters in the function.

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