Forest Health Technology Enterprise Team

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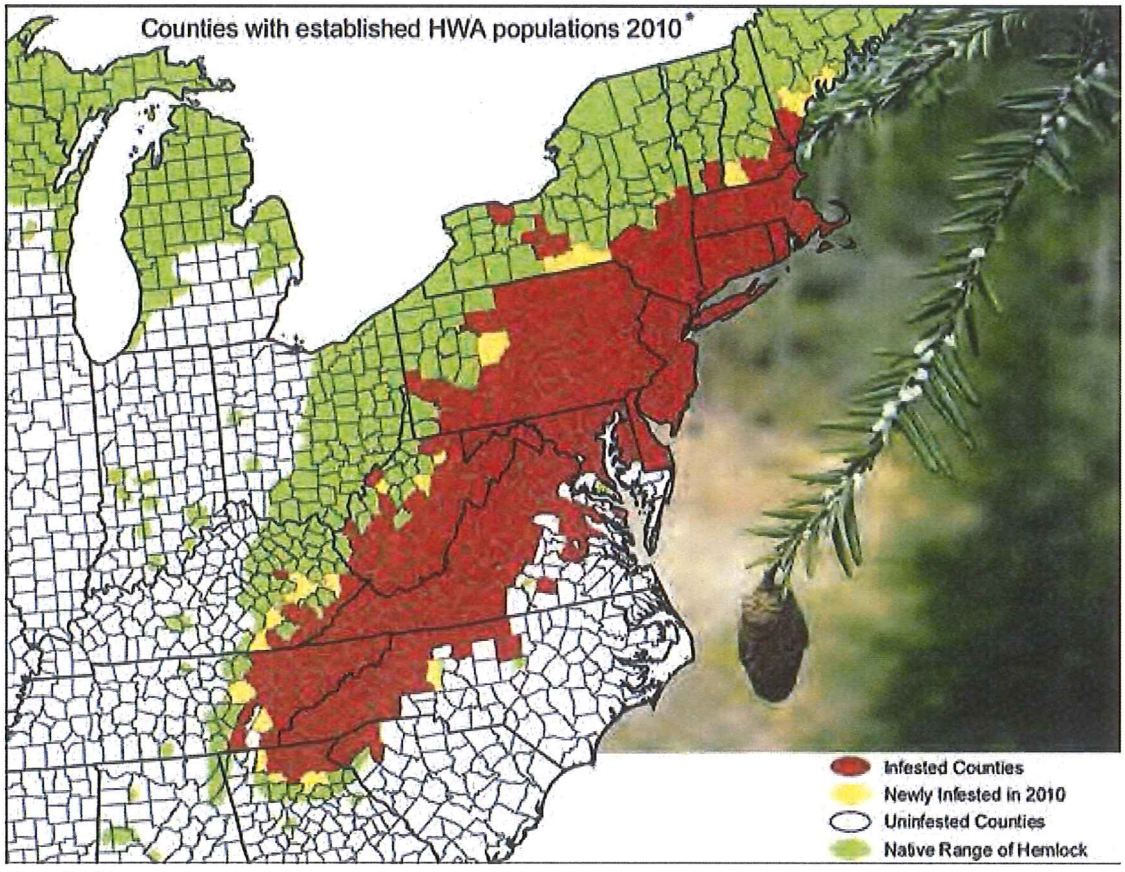

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Developing Process Control and Quality Control in Rearing Systems for Hemlock Woolly Adelgid Predators

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Abstract

We have begun development of process and quality control systems for *Sasajiscymnus tsugae* and *Laricobius nigrinus* mass rearing programs. First, we established the desirable qualities of predators considered highly fit for managing HWA populations after release: survival, search capacity, voracity, fecundity, and longevity. We are using these standards as a basis then establishing secondary standards that are highly correlated with the primary qualities of fitness: weight, sex ratio, protein content, lipid content, carbohydrate content, and free radical scavenging capacity. We are trying to tie output quality of the predators with the processes involved in rearing; thus we are tying **process control** to **quality control**. Next, we developed a preliminary cause and effect diagram (fish bone diagram) to give an overview of the rearing process factors that were pertinent to potential loss of quality (diet, environment, soil {for *Laricobius*}, microbial factors, and handling). Using the Pareto model and past rearing experience, we focused preliminary attention to diet quality and soil. For diet quality, we started with a semi-objective rating system of prey quality (abundance and estimates of prey nutritional value in a scale of 0-5 at 0.5 increments). We are currently tying these estimates to weight per prey item, protein, lipid, carbohydrate, and free radical scavenger contents of prey to enhance objectivity of prey quality assessment. We have also been measuring soil characteristics in soils from under hemlocks and artificial soil mixtures used in mass rearing labs. The characteristics that we are measuring are soil texture profiles, pH, water activity, and organic content. We have also performed tests of *Laricobius* larval (pre-pupal) responses to different soil textures.

Introduction. Several species of exotic and non-indigenous predators are being mass-reared for control of the exotic pest hemlock woolly adelgids. These predators are considered one of the most important weapons in our arsenal against the serious pests that are destroying our eastern hemlocks and threatening Carolina hemlocks; therefore rearing high quality predators in an economically efficient manner is of great importance to forest managers. The laboratories doing the mass-rearing use fairly standardized techniques due to careful coordination efforts by USDA, Forest Service program coordinators. However, because of differences in locations, resources, and personnel, there are some variations in the rearing process, and variations within systems and between systems inevitably lead to variations in quality (Lorraine and Bruzzone 1992 and Cohen 2003). Therefore, our team was funded by the USDA, Forest Service to develop a set of

organizing and coordinating protocols for standardizing and improving the process of mass-rearing of HWA predators and helping the rearing groups develop uniform, logical, and objective standards of quality. We make the distinction between process control (PC) and quality control (QC) as the determination if the steps in the process of product production are within acceptable boundaries or limits vs. the outcome of the process or the product itself being of suitable quality to do the job for which it was intended. In our case, we are trying to assure that the steps taken in mass-rearing the predators of HWA are performed within a defined range (temperatures, food quality, soil characteristics, lowest possible instances of disease, intervals of feeding, cage cleanliness, etc.). At the end of production, our goal is to assure that the predators are produced not only in desirable numbers but that they are sufficiently fit so that when released, they will have a search capacity, longevity, voracity, and persistence in infested sites so that they will control outbreaks of HWA.

The optimal practice in development of process control and quality control would be to develop the standards as a function of extensive collection of relevant data as the process is being initially research and developed. However, most often PC and QC are developed after the fact of working out the procedures, and that is the challenge of the current rearing situation, to go back to the rearing laboratories and collect data that will help us retrofit a PC and QC program to the existing rearing programs.

Materials and Methods

Having several establish protocols and conditions that have been show to work with varying degrees of success, our first step was to collect data on such factors as predator weights, sex ratios, development periods, longevity and other related biological conditions. We are using these parameters and the judgment of personnel in various laboratories to help define the biological range of the predators. We are also trying to collect data on the quality of prey (HWA) at different seasons, the environmental conditions, the degree of disease (mainly microsporidia infections), and a range of biochemical characteristics (protein, carbohydrate, lipid, and antioxidant contents of predators and their food). We have also been working with soils to measure textures of natural and artificial soils used in Laricobius rearing, water activity, water content, pH, and soil textural distribution (sand/silt/clay).

Results

Using PC/QC graphics: we have been developing Pareto charts to help determine the most important or influential factors in the rearing domain to focus our attention most efficiently on whether food quality, disease, environmental factors (temperature, humidity, light conditions, soil conditions, cage characteristics), personnel, etc. are the most significant factors in the control of the process and the products' quality. We have also used fishbone diagrams in conjunction with the Pareto charts to help organize our research focus. Once we have collected preliminary data about the systems when they are working well, we use these data to develop control charts, which have means, upper control limits and lower control limits to help us know when our process is within or going out of control and needs to be adjusted. We are striving to set up protocols for using these

charts on a continual basis to lead to the desired goal of continuous improvement. And we will be developing surveys to help us tie satisfaction of the end-users (stakeholders or forest managers) with our products.

Discussion

So far, though we are very early in or PC/QC research development program, we have found significant information about where the process most often seems to go wrong. For example, our initial Pareto analysis has shown that the primary cause of process failure (mortality of predators) is in the prey quality, including the biomass of prey, protein content, and frequency of food changes (which can be partially offset by using artificial diet when prey are of low quality or not abundant). We have found that balance of temperature and humidity can also be very influential in mold formation, which leads to total failure of the food source. We have also made several important discoveries concerning the soil conditions of Laricobius.

These findings, once they are completed and worked out with the inputs and consensus of the rearing groups, will lead to the production of higher quality, more consistently available, and more fit predators to serve the needs of the forest managers who rely on the predators to find and attack prey with vigor and voracity.

Acknowledgements

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