Evaluation of Seasonal Variations in Carcinops pumilio Dispersal and Potential for Suppression of Dispersal Behavior

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Abstract

Seasonal dispersal of Carcinops pumilio collected using two trapping methods, the Hister House™ and a black light pitfall trap were examined in the laboratory. The black light trap had a numerical collecting advantage over the Hister House™ from March through June. The Hister House™ gathered larger numbers of beetles from June through August and demonstrated less variability throughout the year. During the winter months, beetle collections with both trapping methods were commonly low. These data also document that even when very low numbers of beetles were recovered from manure cores, large numbers of beetles could be collected with the black light trap. This also suggests that beetle density may not be an important factor affecting initiation of dispersal behavior.

Beetles captured with the two trap types had initial dispersal patterns that were significantly different from each other. Carcinops pumilio dispersal was partially explained by the month in which the beetles were collected. However, significant interactions were also observed between the three month effects and both trap type and the trap collection level. Therefore information on multiple effects are needed to fully explain C. pumilio dispersal and potential for field collections.

The greatest dispersal (~90%) in the arenas occurred with beetles collected using both trap types in June 2000. Regardless of trapping method, laboratory dispersal and beetle collections declined from June through October 1999. Following the decline in both trap captures and dispersal rates of beetles in laboratory arenas, we observed a sharp rise in dispersal arenas during November and December 1999. This was followed by a depression of dispersal in January and February 2000. Similar to the trend observed in 1999, beginning in March and ending in August 2000 a rise and then fall pattern in both laboratory dispersal and beetle collections was observed. Although the magnitude of the trap captures in 2000 was not repeated, trap collection patterns were similar to those observed in 1999.

Varied dispersal responses were observed among the beetles exposed to "altered" daylength and feeding regimes. In January and March significantly fewer original cohort black light-collected beetles dispersed than those exposed to a decreasing light regime (held in incubator). In contrast, significantly fewer May-collected beetles dispersed after placement in the incubator where they also received continually shorter daylengths. This suggests that in January and March, we were unable to prevent recruitment of beetles into dispersal behavior, however, in May, after beetles have been in a dispersal phase for several months, we were able to suppress dispersal. In contrast, dispersal behavior among beetles captured with the Hister

House™ did not significantly change following the photoperiod-altered exposure. The interaction of the altered photoperiod and month effects were not significant, suggesting that beetles attracted to or captured by these traps were influenced by other factors.

These results are especially important to producers who want to maximize trapping efficiency and retain the beetles that they introduce to a facility. Because both the type of trap they were collected with and the collection time of year drive beetle dispersal, producers can use this knowledge to either target specific pest problems or as a component in a general pest management program.

Background and Justification

The hister beetle C. pumilio is an effective predator of the house fly, Musca domestica, and is found in many northeastern poultry facilities. Both the adult and larval forms of the beetle feed on fly eggs and small larvae, making it an ideal predator for a poultry fly IPM program.

Adult hister beetles are drawn to and can be effectively trapped in large numbers using black lights suspended in poultry manure pits. However, black light trapped beetles subsequently released into poultry houses are very difficult to relocate in houses, indicating a dispersal response. Recently, IPM Laboratories, Inc., Locke, NY has developed a trapping device called the Hister House™ for capturing hister beetles. Dispersal responses of beetles captured with black light pitfall traps and the Hister House™ were described in Kaufman et al. (2000). In these studies, differential dispersal responses were observed in beetles captured by the two trapping methods. Food was found to be an effective short-term dispersal suppressant (Geden et al. 1987, Kaufman et al. 2000). Several other factors have been presented which may also affect beetle dispersal and colonization including: beetle age, manure moisture conditions, beetle density, and seasonal influences, such as photoperiod.

Recently completed studies at Cornell University suggest that beetle dispersal may be in response to time of year or photoperiod, as well as food availability. Other studies indicated that wild beetles could be successfully captured and transferred from a colonized poultry house to a recently cleaned facility on the same farm providing an excellent, low cost, on-farm source of biological control agents. A transfer of such large numbers of on-farm reared beneficial organisms provides a significant boost to the biological control component of a poultry producers fly IPM program.

In a 1998 pesticide resistance survey of house fly populations collected from NY poultry farms, resistance was extremely high for 6 of 7 registered insecticides examined, including cyfluthrin, the most recently introduced active ingredient (Scott et al. 2000). The benefits of using the hister beetle in an integrated program will become much more important as the implementation of the Food Quality Protection Act progressively removes the few remaining insecticides available to our poultry producers. Several New York poultry producers currently utilize hister beetle transfers. However, these innovative producers are implementing this new technology with little background knowledge regarding optimal deployment of these beetles. Current practices involve releasing as many beetles from one facility into a second as can be collected, at great cost to the producer. If wild captured adult C. pumilio are to be effectively introduced into recently cleaned poultry facilities at various times in the year, a better understanding of the effects of photoperiod and seasonality is critical.

Producers have both indicated and demonstrated a willingness to put extra effort into their poultry fly IPM programs. Many currently spend tens of thousands of dollars purchasing beneficial organisms from commercial insectaries, have several employees that are responsible for cultural control aspects of pest management and schedule manure removal at inconvenient times to reduce the impact of dispersing flies to neighbors. They have a long history of adopting newly developed technology and implementing this knowledge into their operations. We are certain that the results obtained from this study will immediately benefit New York poultry producers.

Objectives

1. Determine if C. pumilio dispersal is dependent upon collection date (time of year).
2. Determine if dispersal behavior can be initiated or suppressed in wild captured beetle populations.
3. Evaluate the seasonality of black light and hister house trapping techniques and determine the optimum application strategy for each.

Materials and Methods

Carcinops pumilio adults were obtained from manure piles in four high-rise, caged-layer poultry facilities located in Wolcott, NY, using the Hister House™, a commercial, disposable trap (IPM Laboratories, Inc., Locke, NY), and black light pitfall traps. Hister House™ traps are 8 x 10 x 6.5 cm cardboard boxes with a nylon screen to allow beetle entrance. Traps contain vermiculite treated with a beetle feeding attractant. When ready for use, the vermiculite is saturated with water and traps are placed screen side down directly on poultry manure. Hister House™ traps were placed one-third of the way up the manure pile on each side of the pitfall traps. Black lights were suspended in the manure pit 2-3 feet above the floor in the depressions between manure rows. On the floor (or manure if accumulations were sufficiently high), under each black light we placed a pitfall trap, a trough constructed from a PVC pipe (20 cm diam by 1.23 m long) cut lengthwise and capped at each end. Manure was piled around the trap forming a ramp that allowed beetles to climb to the edge of the trap. Beetles were collected at 24 hr periods. Following removal from the poultry facility, Hister House™-collected beetles were extracted from traps using Tulgren funnels and black light-collected beetles were separated from other arthropods and debris with brass sieves (12 and 20 mesh). Extracted and sieved beetles were then counted and randomly assigned to treatment groups.

The weight of the field-collected beetles that were gathered at each collection was determined and the number of beetles from each trap type estimated. Beginning in December 1999 and continuing monthly thereafter, four manure cores (400 cc) were taken from the top of the manure cone at least 10 m from the black light trap. Carcinops pumilio were extracted from these cores with Tullgren funnels and enumerated. These data provided additional information regarding the levels of adult beetle activity in the manure.

Dispersal chambers were 1.9 L (16 cm diam) plastic, ice-cream containers, tightly covered with transparent plastic and organdy cloth, and contained a 135 ml (7 cm diam) plastic cup filled two-thirds with moistened house fly diet (8:1:1:4 ratio of wheat bran, wood chips, Calf-Manna™ (Manna Pro Corp., St. Louis, MO) and water). A pipe cleaner was placed across the surface of the diet and level with the rim of the plastic cup to aid in flight dispersal as described by Geden et al. (1987). Beetles dispersing from the diet were captured in 100 ml of soapy water that surrounded the inner container. Fifty adult beetles were placed on the surface of the fly diet and dispersal chambers were sealed. Beetles were counted and removed every 24 hrs for 12 days. Because beetles were unable to climb out of the cup, dispersal was by flight only. Chambers were held in a room with constant florescent light (40 watt) and temperatures of ca. 22 °C. There were 20 replicates for each treatment for each collection method in each of the experiments.

Once a month, for 20 months (February, 1999 through September, 2000), C. pumilio were collected from the poultry farm and placed in dispersal chambers. Every second month, beginning in March 1999 and ending in September, 2000, a sub-sample of field-collected beetles were held in an incubation chamber where we simulated a reverse photoperiod by decreasing or increasing the light:dark photoperiod by 10 min per day for 14 days. In January, March and May, the photoperiod was shortened, while the photoperiod was lengthened for collections made between July and November. This was done in an attempt to either force dispersal in those groups not currently dispersing or to suppress dispersal in those groups that were expressing dispersal behavior. Because the presence of food availability was found to be a factor in suppression of dispersal (Kaufman et al. 2000), we further split the beetles into two additional treatment groups: a fed (house fly eggs) group and starved (water only) group. This resulted in four treatment groups: Hister House-fed, Hister House-starved, black light-fed and black light-starved. In October, an additional group of beetles was included in the photoperiod-altered study because of difficulties associated with the September collection (low beetle recovery and subsequent beetle mortality in the incubator).

Following the 12-day dispersal period, the percentage of beetles that had dispersed was determined and an arcsine transformation was performed on the percent dispersal values. A mixed model analysis was used to examine the percentage of beetles that dispersed from each month's collection and to generate predicted dispersal values. The model statement included trap-type, trap-collection month and the interactions month*month, month*month*month trap-type*month trap-type*month*month, trap-type*month*month*month trap-collection*month trap-collection*month*month, trap-collection*month*month*month. The variables year, dispersal chamber, and trap-type were considered fixed effects in the model. The month of collection and number of beetles collected each month (trap-collection) were continuous effects and allowed for the determination of continual (sequential) beetle dispersal and collection patterns. In other words, were beetles dispersing in response to a time-of-year effect and did trap collections (the number of beetles collected in the two traps) also vary throughout the year?

A second mixed model analysis was performed on the data collected from the photoperiod-altered study. Separate analyses were performed for each trap type and trap collection was not included in the analysis. Beetle dispersal was compared among three groups of beetles; those that were held in the incubator and either fed or starved and the original dispersal group. All other parameters for analysis were the same as previously described with the addition of the photoperiod-altered effect as a fixed effect.

Results and Discussion

The number of C. pumilio collected with each trapping method and the background level of beetle densities in the manure was determined (Table 1). This information will allow producers to determine which method will provide the greatest return on their investment at a given time of year. The black light trap had a numerical collecting advantage over the Hister House™ from March through June. The Hister House™ gathered larger numbers of beetles from June through August and demonstrated less variability throughout the year. When considering that a producer has a limited number of black lights available for trapping, it may be a more effective use of resources to utilize a large number of Hister House™ traps during the mid-to late summer period. During the winter months (November through February), beetle collections with both trapping methods were commonly low. However, fly numbers during this time are also generally low. Producers would be wise to introduce C. pumilio at this time, allowing for populations to build before spring temperatures arrive and the risk of fly dispersal is heightened. These data also document that even when very low numbers of beetles were recovered from manure cores (December 1999, April 2000), large numbers of beetles could be collected with the black light trap. This also suggests that beetle density may not be an important factor affecting initiation of dispersal behavior.

Beetles captured with the two trap types had initial dispersal patterns that were significantly different from each other ($P<0.0001$). This was similar to that reported by Kaufman et al. (2000). The trap collections were found to be significantly different ($P<0.0001$) indicating that different numbers beetles were captured in the various months during the study. All interactions examined (month*month, month*month*month, trap type*month, trap type*month*month, trap type*month*month*month, trap collection*month, trap collection*month*month, trap collection*month*month*month) produced significant differences. This suggests that C. pumilio dispersal could partially be explained by the month in which the beetles were collected. However, significant interactions were also observed between the three month effects and both trap type and the trap collection level. Therefore information on multiple effects are needed to fully explain C. pumilio dispersal and potential for field collections. The actual and predicted values for monthly dispersal are presented with fitted lines (Figures 1a and 1b) that show the changing dispersal patterns.

The monthly average percent dispersal for each trapping method and number of beetles captured per trap are presented in Figure 2. The largest number of beetles captured with black lights (201,000) occurred in April 1999 while the largest Hister House™ collections (4,375) occurred in June 1999. The greatest dispersal (~90%) in the arenas occurred with beetles collected using both trap types in June 2000. Regardless of trapping method, laboratory dispersal and beetle collections declined from June through October 1999. Following the decline in both trap captures and dispersal rates of beetles in laboratory arenas, we observed a sharp rise in dispersal arenas during November and December 1999. This was followed by a depression of dispersal in January and February 2000. Similar to the trend observed in 1999, beginning in March and ending in August 2000 a rise and then fall pattern in both laboratory dispersal and beetle collections was observed. Interestingly, dispersal increased in September after which the study was terminated. Although the magnitude of the trap captures in 2000 was not repeated, trap collection patterns were similar to those observed in 1999.

Varied dispersal responses were observed among the beetles exposed to "altered" daylength and feeding regimes. Behavior exhibited by black light-captured beetles following exposure to an altered photoperiod and feeding regime resulted in significant differences ($P > 0.0001$) between treatment groups. The dispersal differences that were observed between the incubator-fed, incubator-no food and the original cohort regimes were primarily confined to the months of January, March and May (Figure 3a). In January and March significantly fewer original cohort beetles dispersed than those exposed to a decreasing light regime (held in incubator). In contrast, significantly fewer May-collected beetles dispersed after placement in the incubator where they also received continually shorter daylengths. This suggests that in January and March, we were unable to prevent recruitment of beetles into dispersal behavior, however, in May, after beetles had been in a dispersal phase for several months, we were able to suppress dispersal. A significant linear month effect to an altered photoperiod was documented among black light-captured beetles, however, a quadratic or cubic response was not observed as was exhibited with the original cohort beetles discussed previously. Interactions containing the altered photoperiod effect and the linear, quadratic and cubic month effects were also observed, indicating that a relationship exists between light, feeding and the time of year when beetles are captured.

In contrast, dispersal behavior among beetles captured with the Hister House did not significantly change following the photoperiod-altered exposure ($P > 0.7059$), however, as was observed with beetles from their original cohort, similar linear, quadratic and cubic month (time of year) effects were observed (Figure 3b). The interaction of the altered photoperiod and month effects were not significant, suggesting that beetles attracted to or captured by these traps were influenced by other factors. Possibilities include beetle age, physiological state and sex. Previous studies have documented differential dispersal and fecundity responses (indicative of beetle health) by Hister House- and black light-captured beetles (Kaufman et al. 2000; Kaufman et al. in press).

These results are especially important to producers who want to maximize trapping efficiency and retain the beetles that they introduce to a facility. Because both the type of trap they were collected with and the collection time of year drive beetle dispersal, producers can use this knowledge to either target specific pest problems or as a component in a general fly management program. Theoretically, if producers know that following release black light-collected beetles will remain in but disperse across a house this would provide an excellent way to seed a newly repopulated house. Whereas, if Hister House-collected beetles remain in the area where released, they could be used to target fly breeding hot spots. However, we currently do not know the fate of dispersing beetles. This information is essential to most effectively utilize this important biological control agent.

References

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Table 1. Numbers of C. pumilio collected in 24 hours per Hister House™ and black light trap and number of C. pumilio extracted from manure.

Collection Date		House[1]	Estimated No. Beetles per Trap		Beetles per Core[2]
			Hister House	Black Light	
1999	February	2	--	--	--
	March		705	11,542	--
	April		892	200,991	--
	May		318	16,069	--
	June		4,375	33,041	--
	July	12	952	438	--
	Aug		1,565	4,024	--
	September		491	1,817	--
	October		650	1,371	--
	November[3]	2	27	171	--
	December		212	4,682	4.3
2000	January		233	840	28.5
	February		552	425	9.3
	March		216	682	12.0
	April		189	4,471	2.5
	May		1,721	1,385	34.0
	June		688	2,530	16.0
	July	8	203	1,106	45.8
	Aug		106	11	42.8
	September		37	43	32.8

[1] House 2 repopulated April 1998, House 12 repopulated October 1998, House 2 repopulated June 1999, House 8 repopulated August 1999.
[2] Average of four manure cores (400 cc) extracted using Tulgren funnels.
[3] 48 hour collection.

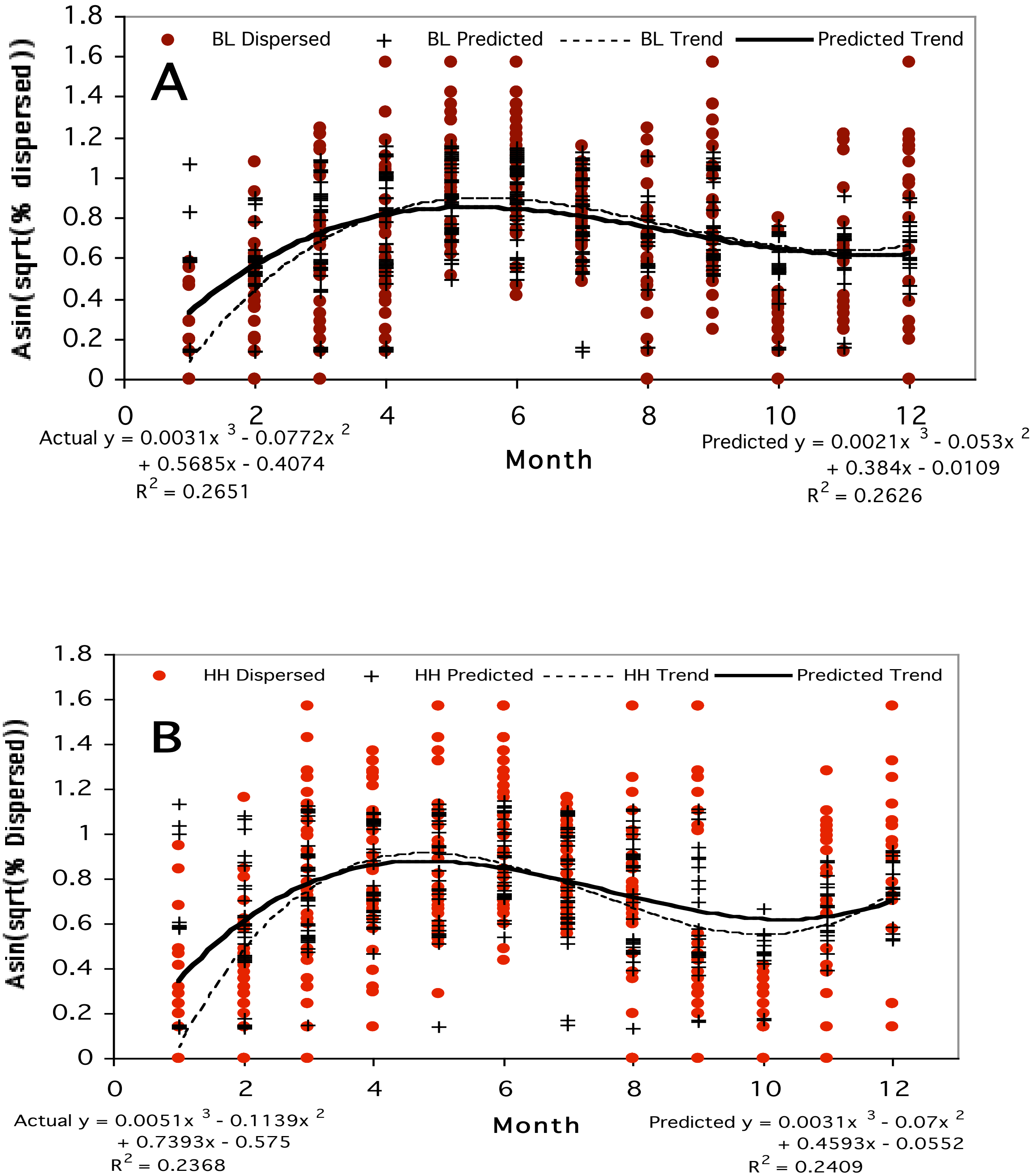


Figure 1. Yearly dispersal pattern for black light- and Hister House-collected C. pumilio.

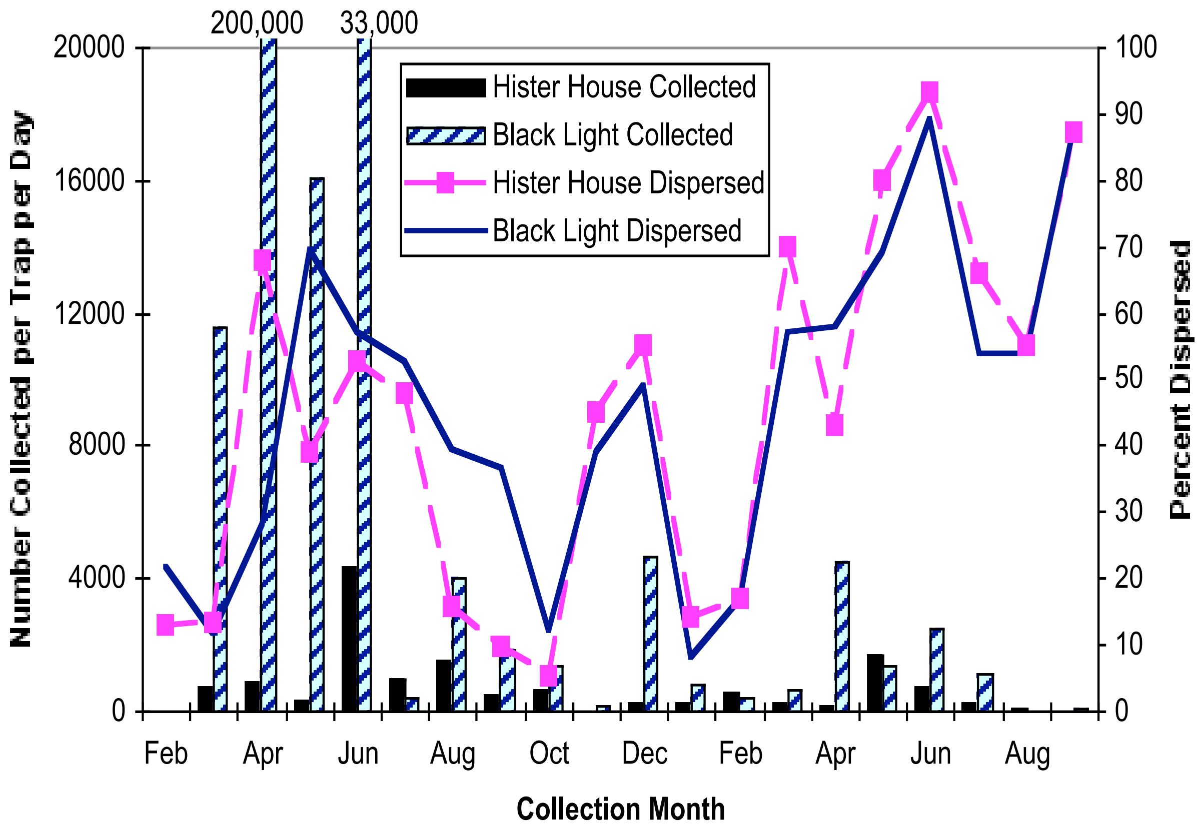
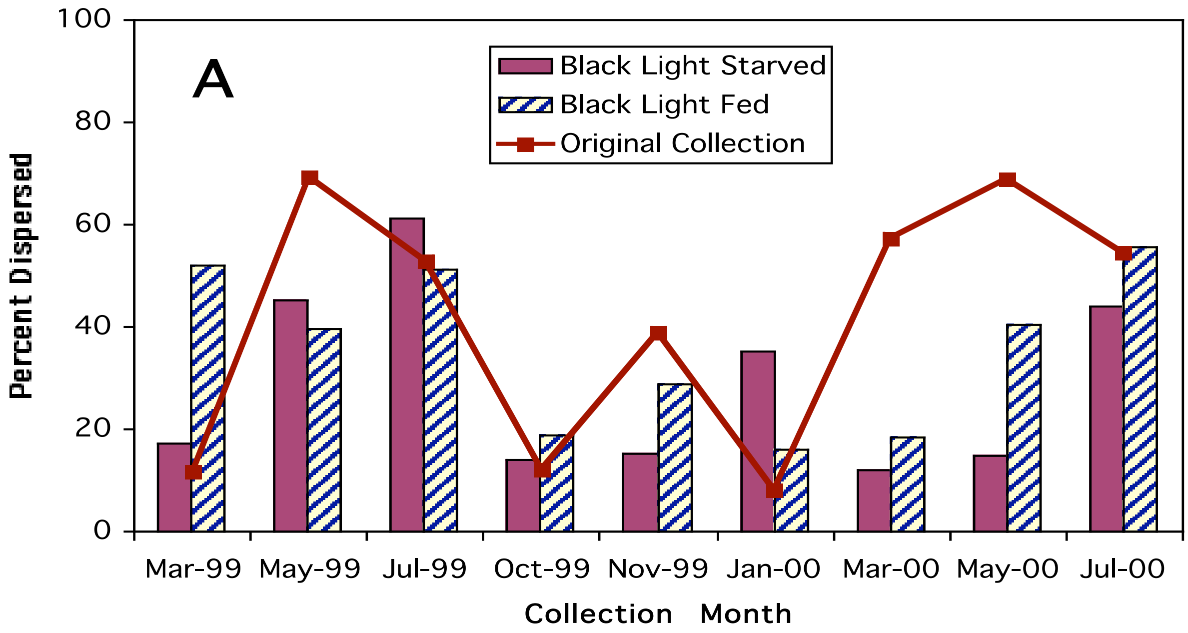


Figure 2. Monthly collection and dispersal of C. pumilio collected using two trapping methods during 1999 and 2000.



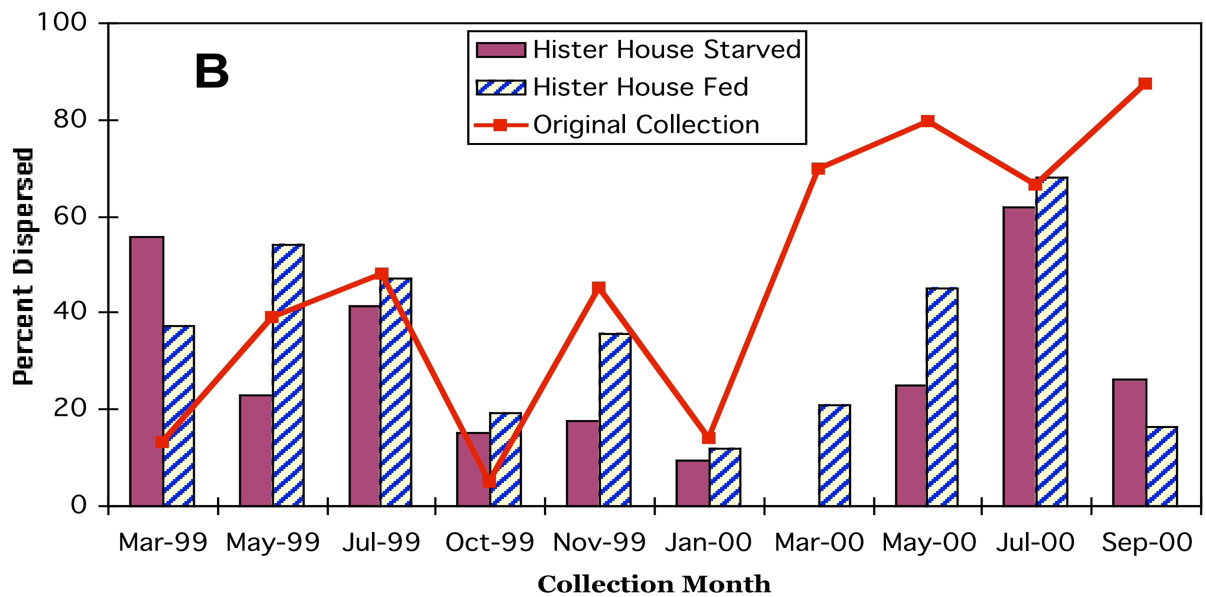


Figure 3. Dispersal of black light- and Hister House-collected <u>C</u>. <u>pumilio</u> immediately following collection and following a two-week photoperiod alteration.