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THE UTILIZATION OF TRAINED DOGS FOR DETECTION AND SURVEY OF GYPSY MOTH (LYMANTRIA DISPAR L.) EGG MASSES

presented by

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has been accepted towards fulfillment of the requirements for

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Dean L. Haynes
Major professor

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THE UTILIZATION OF TRAINED DOGS FOR DETECTION AND SURVEY OF GYPSY MOTH (LYMANTRIA DISPAR L.) EGG MASSES

By

Thomas Lee Ellis

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ABSTRACT

THE UTILIZATION OF TRAINED DOGS FOR DETECTION AND SURVEY OF GYPSY MOTH (LYMANTRIA DISPAR L.) EGG MASSES

By

Thomas Lee Ellis

Three German shepherds were trained to detect disparlure and egg masses of the gypsy moth, *Lymantria dispar* (L.), under laboratory and field conditions. One of the dogs proved to be inadequate due to its temperament. The performances of the two remaining dogs were evaluated under varying environmental conditions and egg mass densities.

Both animals found egg masses at approximately the same rate, i.e., rate of capture (egg masses per minute), while searching plots of similar densities. It was also found that the dogs exhibited many of the characteristics of vertebrate predators during their search routines. Climatic factors and the time of day seemed to have little effect on the performances of the animals. The dogs had great difficulty detecting egg masses containing >50 viable eggs and they could not detect "dead" egg masses. A training manual containing information such as breed and individual selection, testing, and training (obedience and olfaction), etc. was compiled.

DEDICATION

I suspect that in the harsh light of reality most theses are considered a chore. Mine was an adventure of the highest magnitude! I am thankful for that and for those that made it possible.

Among others my deepest thanks go to Bill Wallner for making this odyssey possible, to Glen Johnson, a truly gifted man and a master craftsman, and to Dean Haynes for being my friend and for sharing with me the agony of retrospection.

I dedicate this work to the one person who shared it all with me - my wife and lifelong friend, Alice.

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INTRODUCTION

Periodic occurrences of gypsy moth, Lymantria dispar L., in Michigan have been reported for more than 25 years. One such report was responsible for the initiation of this research project.

During the summer of 1972 a trap baited with the synthetic pheromone "disparlure" captured a male gypsy moth near the village of Winn, Michigan (Isabella County) (Hannah, Personal Communication 1972). Subsequent investigation of the adjacent woodlot by Michigan Department of Agriculture personnel noted a heavy, but localized, infestation[1].

The woodlot was sprayed the following spring (1973) with Sevin-4-Oil in an effort to eradicate the pest. A short time after the spray application the area was inspected to determine the effectiveness of the control measures. It was discovered that very few of the egg masses had hatched. Samples were collected and expamined microscopically to determine what percentage of them had eclosed.[2] Of the eggs examined approximately 93% of those oviposited more than one meter above the ground had not survived while 65% of those laid below one meter or on ground litter had survived. Leonard (1972) reported that vertical

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[1]Traps baited with disparlure are widely used to detect new infestations but the standard population estimate has been egg mass density.

[2]Dead pherate larvae = egg mortality.

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Stratification occurs, with eggs deposited closest to the ground suffering the lowest degree of mortality at low air temperatures. Summers (1922) and Maksimovic (1958) have shown that exposure of egg masses to very low temperatures (-20^{o}F) will kill all eggs within a mass.

Local weather records were consulted (Mt. Pleasant Michigan Agricultural Weather Network recording station 15 miles north of Winn) to verify the observed phenomena. For the winter of 1972-1973 the lowest recorded temperature was -15^{o}F preceded by an unseasonably extended warm period (January 15 to February 5). Literature concerning egg development and diapause was consulted and it was found that a possible link between alternating temperatures and the breaking of diapause may exist (Zlotin and Treml' 1964). From this and other relevant literature (Maksimovic 1958) it seemed plausible that normal fluctuations of winter temperatures in 1972-1973 could have been responsible for the high mortality experienced by the Winn infestation.

A series of experiments was designed to test this hypothesis. Field-collected eggs would be subjected to various temperature regimes to determine the cause and effect relationship between fluctuating temperatures and overwintering mortality of the egg masses. To facilitate this research project it was determined that egg masses collected in Michigan would be the most suitable for evaluation (Downes 959).

Finding egg masses proved to be an impossible task. Human detection of egg masses in sparce populations is difficult because of the high percentage of masses laid near the ground either in the litter or under bark flaps (Campbell et al., 1975).

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The failure to find egg masses in the field was directly responsible for the creation of this research project. In March 1974, under the direction of Dr. William Wallner, this project was initiated. The premise was the development of a detection technique which did not depend solely upon visual detection of egg masses.

Most organisms emit odors which, because of their complexity and low rates of emission, may be difficult to characterize chemically. Other emissions, such as the male sex attractant pheromone of the gypsy moth, L. dispar L., have been isolated and identified (Bierl et al., 1970). Differences in emission rates of the pheromone among laboratory reared and wild female gypsy moths have been reported (Block 1960). However, no odor system has been identified from the egg mass.

The training of domestic canines for hunting and tracking biological organisms has long been accepted practice. While different breeds of dog are capable of being utilized as working animals, the German shepherd has a history of working dog excellence (Humphrey and Warner 1934). They have been trained to detect inanimate objects such as drugs, firearms, explosives, and gas pipeline leaks even though the exact mechanism for scent discrimination is unknown (McCartney 1968). Canine detection sensitivity has been reported for idoform at 400 parts per billion (ppb), sulfuric acid at 100 ppb (Buytendijk 1932) and butyl mercaptan at 1 ppb.

With this base of knowledge three broad objectives were identified:

1. To determine whether or not egg masses of the gypsy moth emit an odor that is dectable by a dog.

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2. To determine whether or not a dog could be trained to find egg masses under field conditions.

3. To determine whether or not a dog trained to find egg masses in the field could do so in a quantifiable manner.

This thesis is the development of a series of scientific events. Each event tests one or more hypotheses and the results generate new hypotheses to be tested. So that the reader can have a better understanding of the events a chronological time line has been developed to held guide the reader.

<u>January 1972</u>

- Winn infestation discovered

<u>January 1973</u>

- Winn infestation sprayed
- High mortality discovered
- Overwintering mortality project initiated

<u>January 1974</u>

- Overwintering mortality Project abandoned
- Dog # 1 procurred
- Dog # 1 finds disparlure in laboratory
- Dog # 1 finds egg masses in lab
- Dog # 1 finds egg masses out-of-doors
- Dog # 1 proves unsuitable for further training

<u>January 1975</u>

- Dog # 2 procurred
- Dogs # 2 and # 3 trained
- Pennsylvania field experiments (dogs # 2 and # 3)

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- Matrix experiment (dog # 2)

- Dog # 2 turned over to U.S. Forest Service

January 1976

This thesis is divided into two major parts. Part I will deal with the methods and materials and results of preliminary testing and field experiments. Part II consists of a training manual that was developed during the course of this research project.

Most scientific works dealing with canine olfaction are qualitative and, therefore, quite subjective. It is hoped that this work will lead to a greater appreciation of these animals in a quantitative sense and will enhance future inquiries utilizing the olfactory capabilities of dogs.

PART I

ANALYSIS AND EVALUATION

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METHODS AND MATERIALS

Three test animals were utilized to complete the research for this thesis. Dog # 1 was recruited before candidate screening techniques were available to the project. When these techniques became available, dog # 1 scored low on both the temperament and parasympathetic nervous reaction tests (Part II). Dog # 1 did, however, possess the olfactory qualities necessary to discriminate for objects treated with disparlure in the laboratory and for nylon hosiery bags containing gypsy moth egg masses.

Dog # 2 was selected according to the criteria established in Part II. Before this animal was selected more than 500 German shepherds were evaluated.

Dog # 3 belonged to Mr. Glen Johnson of Guardian Training Academy, Windsor, Ontario, Canada. This German shepherd was a veteran tracking dog and had received much acclaim for its olfactory excellence. Mr. Johnson was contracted to supervise the olfactory training and to serve as a consultant to the project.

When training dogs to scent discriminate, great care must be taken not to contaminate the scented objects with foreign odors. As a precautionary measure, procedural checklists were constructed and followed exactly. Great care was taken to sterilize all handling equipment (forceps, rubber gloves, etc.) prior to each experiment or

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training exercise. Whenever a substrate or artifact was associated with the scent (pieces of wood, nylon hosiery, etc.) great care was taken to assure they were of uniform size, shape, color, etc.

Part I consists of two phases (preliminary evaluation and quantitative analysis of field trials). The preliminary evaluation consisted of laboratory and out-of-doors tests of dog # 1 and a qualitative evaluation of the behavioral aspects of a searching dog.

Dog # 1 was evaluated for his ability to scent discriminate for objects treated with disparlure and for nylon hosiery containing gypsy moth egg masses. According to Beroza et al. (1971), 1-6 μg of disparlure approximates the attraction of a live virgin female gypsy moth. To test this rate, 5 μg of disparlure was pipetted to fifty 25 x 6 mm pieces of wood, plastic, and metal. Objects were prepared and handled with sterilized rubber gloves and forceps so as not to impart the odor of the handler. In a span of 3.5 months, four training periods consisting of 50 replicates of one treated and two untreated objects were offered for each substrate. Trials with different substrates were run simultaneously so that the dog would select the one common odor which was disparlure. After each trial all articles were discarded whether selected or not. This phase of the project was necessary to convince prospective grantors that even though this project was very unusual and novel, it had scientific potential. It was also necessary from the standpoint of convincing regulatory agencies to allow the University to bring egg masses into Ingham County (a quarantined area) for further experimentation.

Field collected gypsy moth egg masses were obtained from Dr. C. Swhelby, Otis AFB, Massachusetts via APHIS, USDA permit and through the cooperation of Mr. Dean Lovitt, MPI, Michigan Department of Agriculture. To prevent breakage or loss of eggs in the training and evaluation process, the eggs were placed in nylon hosiery material and then into perforated Maujet polyethylene injection capsules or taped paper toweling. As in the disparlure scent discrimination process, the object containing eggs was hidden in the laboratory as were two similar egg-free objects, and then the dog was commanded to locate and retrieve the one containing eggs. During the first month the containers were hidden out of the dog's sight in various locations on the laboratory floor.

When the indoor phase of the experimentation was completed, the experiment was moved to a suitable location out-of-doors (MSU Horticultural Garden). This location presented the dog with environmental conditions similar to actual field conditions. Outdoor selection included hiding the containers (one with egg mass and two without) under straw, leaves and refuse, under snow cover, or in shrubbery, and working the dog on a 2 m long leash. The dog was worked into the prevailing wind and allowed to make three passes over the area of the concealed containers (each area contained three possible choices 1 m apart). Inability to scent the egg packet and retrieve it was considered a failure.

The second phase of the experimentation was conducted in the Bald Eagle State Forest (Pennsylvania) and at Michigan State University. Dogs # 2 and # 3 were the test animals utilized.

The area surrounding R.B. Winter State Park in the Bald Eagle State Forest was defoliated extensively by the gypsy moth in 1975 (Figure 1). The area presented an ideal testing ground for the research project. It offered the full range of environmental and topographic gradients necessary to test the effectiveness of the searching dog.

The areas utilized for the research were all near the R.B. Winter State Park (Figures 2 and 3). The forest in this area is made up primarily of chestnut, white, and red oaks. The understory, where present, was Mountain Laurel and/or Low Bush Blueberry. Occasionally rhotodendron appeared in low moist areas.

The topography of the area was quite diverse. The test plots were representative of the broad range of slope, elevation, and substrate available in the area. Slope ranged from 0° to approximately 45°. The substrate consisted mostly of eroded bluestone ranging in size from 10 mm to several meters in diameter. This type of flora and substrate offered ideal ovipositional sites for the gypsy moth. The plots were located in low-lying pockets in the forest as well as ridge tops.

Once the dogs demonstrated that natural, non-manipulated egg masses could be detected, two methods of search were evaluated (Figure 4).

The first was a series of ten .01 ha. plots (area plots) in each of four different geographical locations of suspected varying population densities near the park. The plots were square with each corner marked with a 1.5 m x 6 mm wood dowel with colored plastic flagging attached. The plots were laid out along a 1.609 km compass course at each 0.161 km (.1 mile). The dog was directed to search into

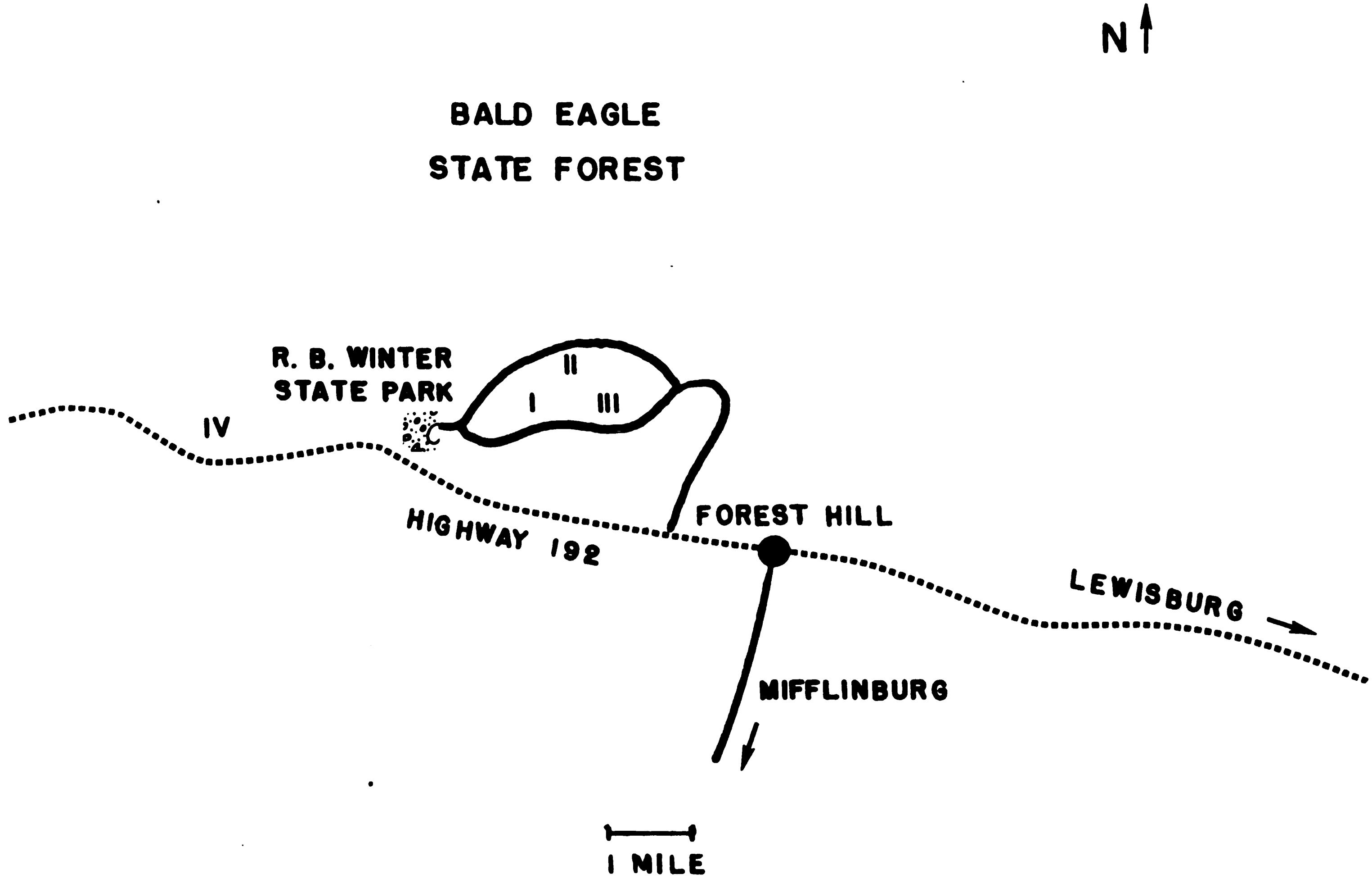

Figure 1. PENNSYLVANIA-FIELD RESEARCH AREA

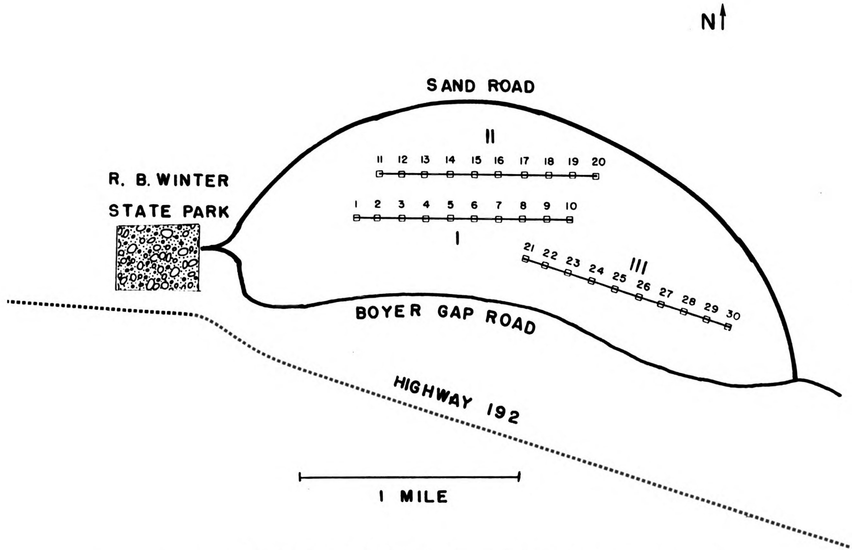

Figure 2. PLOT DIAGRAM (AREA'S I, II, III)

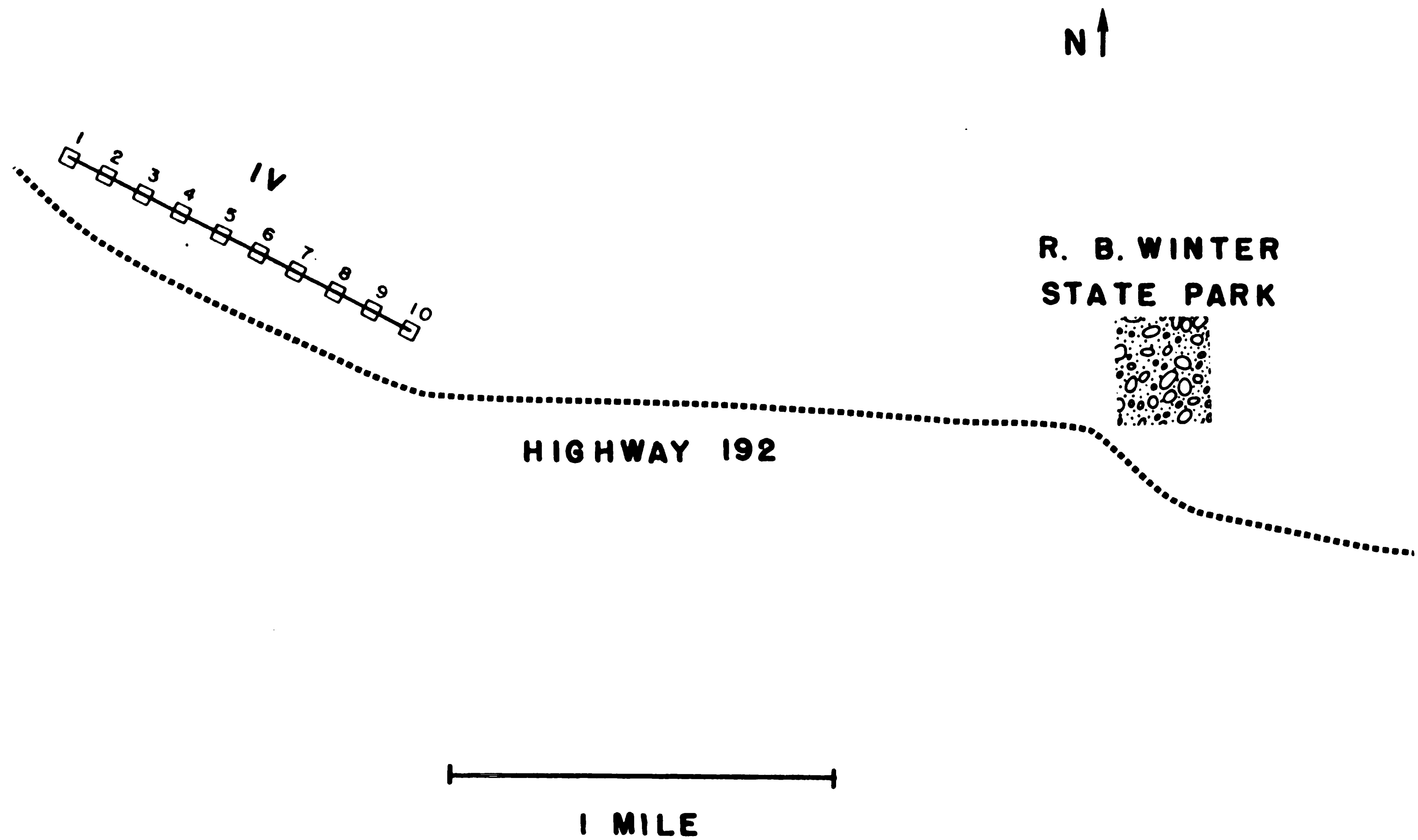

Figure 3. PLOT DIAGRAM (AREA IV)

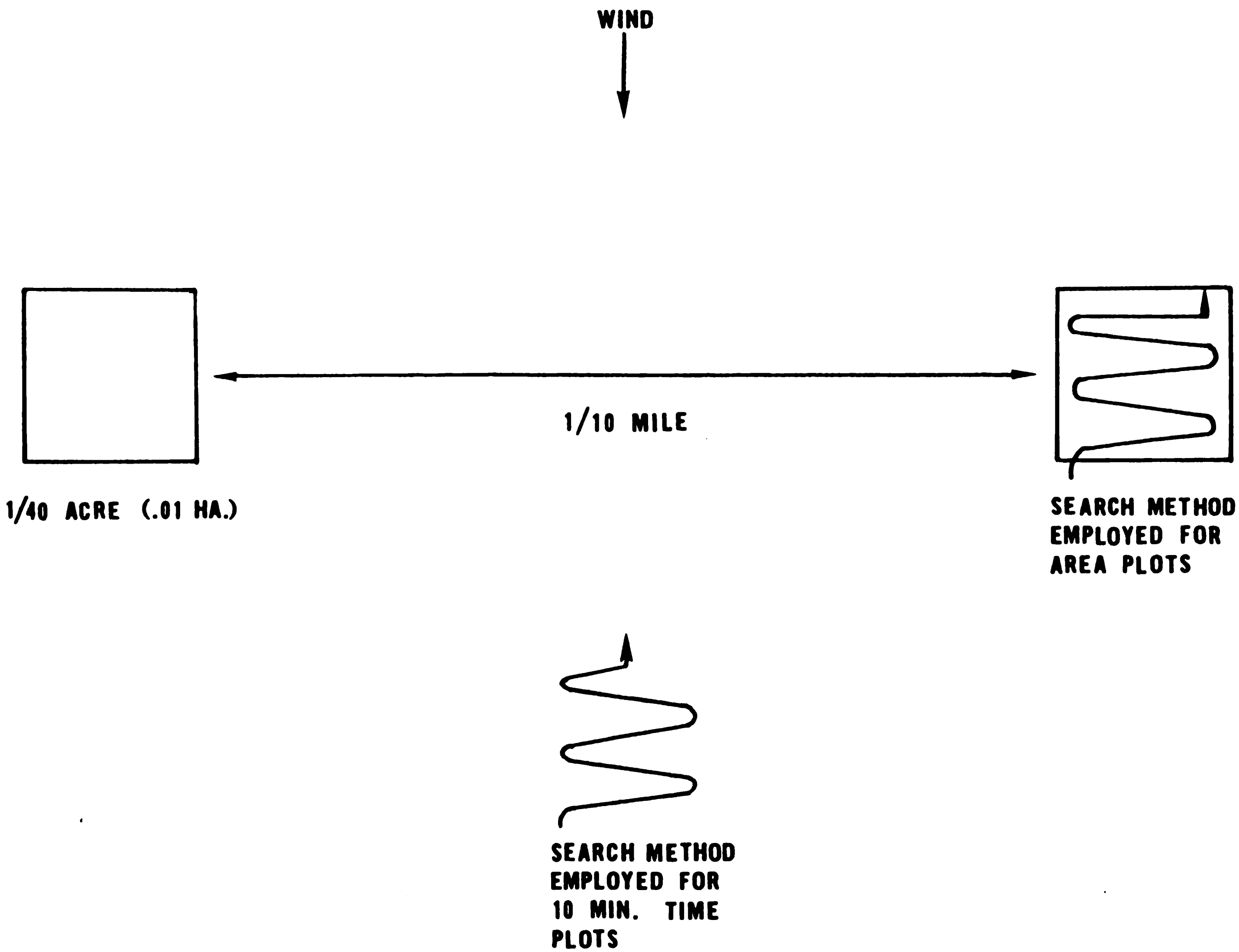

Figure 4. Two search patterns utilized in field trials

the wind, traversing back and forth so that every portion of the plot was covered. He was not allowed to search any portion of the plot more than once. When an egg mass was indicated it was marked by a 1 m metal wire stake with flagging and the dog was allowed to continue until the search was completed. After the dog had completed his search, each plot was thoroughly examined by one man for 30 minutes. All stones, logs, and other debris on the ground up to a height of 1 m were examined for the presence of egg masses missed by the dog.

The second search method was undertaken in an attempt to correlate the intensively searched 0.01 ha. plots with the population density of the surrounding area (time plots). The dog was allowed to search freely, but not within previously searched area plots, for 10 minutes. Egg mass finds were marked in the same fashion as were the area plot searches. No subsequent search was conducted by man except to verify each egg mass indication. In each of four areas, 20 such searches were conducted. The dogs indicated egg mass finds by retrieving or attempting to retrieve the object containing the egg mass. When an object could not be retrieved, the dog would bite or dig at the location.

Prior to each searching exercise the following climatic parameters were measured: temperature, relative humidity, and wind speed. The temperature was recorded at a height of .71 m (approximately the height of the dog's muzzle). The relative humidity was taken on the perimeter of the search area with a hand-held hygrometer. The wind speed recorded was a five minute average taken prior to each trial with a hand-held cyclometer. This reading was also taken on the perimeter of each search area at a height of .71 m.

RESULTS

Preliminary Testing

Disparlure Discrimination

Dog # 1 was capable of locating disparlure-treated objects at a distance of up to 2 meters away in the laboratory. Once he was capable of scent discrimination his proficiency for detection increased (Table 1).

Table 1. Success by a German shepherd to select for disparlure on different substrates in the laboratory.

Substrate	Testing Order of each 50 Replicates[a]	% Positive Selection
Wood	1	82
	2	94
	3	96
	4	94
Metal	1	70
	2	76
	3	88
	4	90
Plastic	1	50
	2	68
	3	68
	4	70

[a]Each replicate consisted of 1 treated and 2 untreated objects. The order of testing of the different substrates was altered with one another.

This improved proficiency for discriminatory quality and working ability in tracking was reported by Syrotuck (1972) to be correlated with regular practice. When the disparlure was placed on metal or plastic, the capacity to locate it was less than when placed on wood chips. The reason for this disparity was unknown at the time. Experimentation with subsequent animals indicated that plastic containers imparted odor on the egg masses stored in them. When commanded to retrieve a "plastic" stored egg mass, the dog did so. It was discovered that dogs trained to find the plastic stored egg masses could not locate egg masses not stored consistently. It was concluded that the animal associated the plastic odor with that of the desired behavior (a correct response) and the plastic odor evidently competed with the odor of the egg mass.

During the first experiment the objects to be treated were occasionally stored in plastic bags. The researchers believe that this was reflected in the lower percentage of success with the plastic objects.

Egg Mass Discrimination

One hundred and thirty-seven trials were completed in the laboratory (Table 2).

Table 2. Egg mass discrimination trials (indoors)

No. of Trials	No. of Egg Masses Retrieves	No. of Blanks Retrieved[a]	No. of No-retrieves
137	128	6	3
	93.4%	4.4%	2.2%

[a]Blank is the term used to represent an object containing no eggs.

The high success rate experienced in the laboratory indicated that the dog was near perfect under these conditions and was ready to continue the experimentation out-of-doors. The brevity of the transition period, i.e., scent discriminating for disparlure to egg masses, suggests that there is at least a similarity between the two odor systems. An attempt was made to evaluate the odor disseminating from the egg mass. Mass spectrographic analysis was unable to detect or quantify the odor of an egg mass at that time (Zabik, personal communication, 1975).

Out-of-doors the detection efficiency was low in September and October (Table 3), but gradually increased throughout the testing period. Interference of odors from plant materials, soil, etc., not encountered in the laboratory is believed to have influenced the initial decreased efficiency.

Table 3. Egg mass discrimination (out-of-doors)

Month	No. of Trials	No. of Masses Retrieved	No. of Blanks Retrieved	No. of No-retrieves	% Success
Oct.	58	14	20	24	24.1
Nov.	37	6	11	20	16.2
Dec.	16	9	4	3	56.2
Jan.	60	41	11	8	68.3
Feb.	30	23	5	2	77.0
Mar.	40	38	2	0	95.0

Quallitative Evaluation of the Search Sequence

During the course of the training exercises and experimentation observations were made concerning the behavioral traits associated with the dog during the search process. It was felt that if the searching sequence could be characterized as a series of events leading to the successful capture of an egg mass the researchers would have a better understanding of the research tool (dog) and the project, as a whole, would benefit.

The behavior of a vertebrate predator searching for prey is described by Holling (1959b). The differences in the behavior of the searching are subtle. The behavioral activities associated with the handling and ingestion of prey are modified to become the conditioned responses associated with searching. The seven components of the search sequence have been identified as: the controlled search, recognition, pursuit, identification, capture, retrieval, and reward.

No attempt was made to quantify the components of the search sequence. At that time the project was not conceptualized as a predator/prey study. The identification of the components of the search was made from independent observations in the field and of Super 8 mm movie film taken of dogs #2 and #3 searching several of the .01 ha. plots.

The behavioral response best characterizing the controlled search is a dog searching into the wind who still responds to directional signals from the handler.

The controlled search component was a product of specific behavioral inputs incorporated into the training regime. The training was structured to emphasize the use of olfactory senses and dissuade the reliance upon others.

The predator searches for prey to satiate its hunger. Holling (1956) reported that the predators' hunger is greatest at the beginning of each feeding period. The same conditions were duplicated for the searching dog of this project. The feeding period was replaced with the working period. The dog's daily meal was synchronized to be the climax of the working day. Even though the dog was given food rewards during the working period the amounts were small and considered enticement rather than satiating.

The action of the predator searching for prey is dominated by time. Holling (1955) points out that these activities are dependent not only upon conditions at the time of the search but also upon events and conditions of previous search activities. This was incorporated in the training in two ways. Once the desired response was expressed by the dog, i.e., the successful completion of the objective of a particular training exercise, it was repeated until the proper behavioral response became habitual. The dogs were trained to cover the greatest possible distance in the shortest period of time while searching. The methodology was designed to eliminate time lags and subsequently increase the efficiency of the controlled search.

<u>The recognition response was best characterized by the dog suddenly abandoning the controlled search pattern and testing the air in a particular direction</u>.

The searching action of the predator is a functional response to its hunger. The first threshold encountered is the recognition of the presence of prey. The same is true for the searching dog. When the searching dog reaches the recognition threshold, there is a tensing of the related muscles of the head and front quarters, an abandonment of the search pattern, and a positioning of the body to face the wind and best exploit the odor source.

The response of the dog when it reached the recognition threshold was observed to be different depending upon the dog's age and previous work experience. The younger and less experienced canid searched at a faster rate than the older and more experienced dog. Upon reaching the recogition threshold one of two responses was noted. The dog either made the transition from the search behavior to the recognition behavior as described or the response was partial and the transition negated. The partial response was characterized by a slight turn of the head and forward portion of the torso towards the direction of the egg mass. This response usually resulted in the continuation of the search behavior. It was hypothesized that the behavior expressed was directly related to three factors: the searching speed of the dog, the linear distance of the dog from the odor source, and the extent of previous training.

<u>The pursuit response was best characterized as a mobilized continuum of the recognition behavior towards the odor source</u>.

The pursuit sequence was initiated when the dog made positive movement towards the recognized egg mass. The sequence ended when the animal stopped to investigate the suspected location of an egg mass.

The mode of action associated with the pursuit of prey by a predator is the result of adaptive radiation and behavior of both the predator and prey (Holling 1959a). The complexity of the pursuit component is a direct result of the complexity of the sub-components (the behavioral response that the predator employs to counteract the evasion tactics employed by the prey). For a predator to be successful, it must adapt to changes incorporated by the prey. The same is true for prey. If it is to survive it must adopt those characteristics that offer the greatest chance of survival.

The gypsy moth exhibits many characteristics that enhance its chance of survival. Morphological form, coloration, and size contribute to the survival of the adult form. The egg mass may also benefit from evolutionary adaptations. The egg mass is cryptically colored and its size and shape conform to the relief of the ovipositional site.

Birds and mice are the principal vertebrate predators of the egg mass (Britton 1935). These predators hunt primarily by sight. It seems that many of the selective changes have evolved to protect the egg mass from visual discovery. The training regime was designed to dissuade the use of visual detection and reinforce the use of olfactory senses. By discouraging the use of other senses the greatest chance of failure during the pursuit would be the animal's inability to follow the scent trail. Positive reinforcement of olfactory success would focus physiologically and behaviorally oriented processes to respond exclusively to odor stimuli.

The identification component is best characterized by the dog using olfaction to identify the exact location of the egg mass by excluding all other possible locations immediately upwind of the suspected egg mass location.

During the scent discrimination training the dog was forced to identify the scented object in close proximity to similar but untreated objects. To be successful the animal had to pinpoint the scent source of the odor. The dog found that this task was best accomplished by excluding the unscented objects by the process of elimination. Once the animal was successful using this method of identification the response seemed to become habitual. This learned response carried over to the identification of an egg mass. The animal would verify the exact location of an egg mass by moving around the suspected location and exclude by olfaction all other possible sources of scent in the immediate area.

The capture component is best characterized by the dog securing or attempting to secure the egg mass with its mouth.

The dog capturing an egg mass was the result of two distinct actions. The animal would initially bite at the mass and then attempt to tear it free from the ovipositional site. Movement supportive to the actions was often observed. The dog would quite often dig and scratch with its front paws to aid in the capture of the prey.

The retrieval component was best characterized by the retrieval or attempted retrieval of the captured egg mass.

Holling's (1959) study of predator-prey relationships indicated that predators spend some time after the capture and prior to ingestion handling the prey. Many times a predator will move its captured prey to a more defendable location prior to ingestion. The handling response could also give the predator time to physiologically adjust from the hunt to feeding.

Handling time of the prey in this study was the retrieval of the egg mass. Retrieval of the egg mass for a reward was a response reinforced during prior training. Unlike previous training the egg mass was not always retrievable. The animal was encouraged to attempt to retrieve all egg masses. This served a dual purpose. It reinforced the retrieval response and it also kept the animal at the location if the substrate was not retrievable. This eliminated the problem of the dog making a positive indication out of sight of the handler. By remaining at the egg mass location the handler was given time to find and verify the possible egg mass location. Attempting to retrieve the static egg mass was manifested in several ways: digging, scratching, rolling over rocks, and biting at trees.

The reward response was best characterized by the dog showing overt signs of partial satiation and being ready to resume the search sequence.

The logical endpoint of the searching predator is the ingestion of the captured prey. Several training exercises were devoted to letting the dog ingest captured egg masses. Even though the dog eagerly accepted this as a reward, it was found that the protective hairs on the egg mass were unpalatable, causing the dog to reject the egg mass.[3] The reward for the successful completion of the search sequence became positive reinforcement utilizing a small amount of food, verbal acclamation, and stroking the animal's coat.

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[3]In 1977 and again in 1978, dog # 2 had nodules removed from his nasal passages. After the second operation samples were sent to the U.S. Canine Corps for section analysis. As of this writing results are inconclusive but enough concern has been raised to warrant air sample analysis from the Forest Service rearing facility in Hamden, Connecticut.

The timing of the reward to attain a consistent performance over a long period of time was also investigated. Ferster and Skinner (1957) reported that a constant reward ratio for initial training and a variable ratio schedule of positive reinforcement produced a high overall rate of response in test animals. This method was adopted and seemed to be suitable.

Quantitative Analysis of Field Experiments

Area Plots

Dogs # 2 and # 3 located egg masses in the field on substrate types ranging from stones and branches to the bark of tree trunks. While it was difficult to accurately establish the exact distance from the egg mass when the dog made the initial detection, all indications seemed to have been made at 2 m or less.

Searches by the dogs and verification by human examination showed that four different densities of egg mass existed (Table 4). Preliminary examination of the data seemed to indicate that dog # 3 (the older and more experienced dog) started and remained at about the same level of effectiveness while the younger dog (dog # 2) (Table 5) started out more slowly but improved rapidly. If the work exercises are grouped as chronological work events (Figures 5 and 6), one can readily discern the differences between the two test animals. It will be shown later in this section that even though dog # 2 went through an initial lag early in the exercise the rate at which he found egg masses (egg masses per minute) was not affected. For the purpose of this study the author will define "effectiveness" as the percentage

Table 4. The effectiveness of two German shepherds to find egg masses in 0.01 ha. plots, R.B. Winter State Park, Pennsylvania State Forest, August 1975.

	Number of Egg Masses Found by the Dog/ Number Present in each Plot.[a]		Average Time of Search/Plot (min)	
Egg Mass Density/ha.[b]	Dog # 2	Dog # 3	Dog # 2	Dog # 3
200	12/20 (50%)	6/8 (75%)	9.2	9.9
470	7/11 (64%)	18/26 (69%)	8.1	11.1
570	6/12 (50%)	25/27 (93%)	11.7	13.6
2400	75/87 (86%)	50/57 (88%)	14.3	13.3

[a]The total number of egg masses between 0-1 m from the ground found by the dog plus those additionally found by a man intensively searching the same plot for 30 minutes.

[b]Estimate based upon ten 0.01 ha. plots.

Table 5. Chronological detection effectiveness of two German shepherds in finding gypsy moth egg masses. R.B. Winter State Park, Pennsylvania State Forest, August 1975.

	Chronological Order and Number of Egg Masses Found by the Dog/Number Present in each Plot.[a]
Dog # 3	13/14, 7/7, 1/1, 2/2, 1/2, 1/1, 5/7, 6/8, 4/6, 1/2, 2/2, 2/2, 1/1, 0/1, 3/4, ---, 21/22, 17/19, 12/16[b]
Dog # 2	2/4, 2/2, 0/2, 1/1, 3/4, 0/1, 1/2, 2/3, 1/3, 3/4, 2/3, 2/6, ---, 2/2, 6/8, 8/10, 23/25, 2/2, 1/1, 13/16, ---, 1/1, ---, 12/13, 7/10, 6/6[c]

[a] The total number of egg masses between 0-1 m from the ground found by the dog plus those found by a man intensively searching each 0.01 ha. plot for 30 minutes.

[b] There was no trend for improved effectiveness to detect egg masses according to Mann's Trend Test.

[c] The trend for improved effectiveness to detect egg masses is significant (P=0.01) according to Mann's Trend Test.

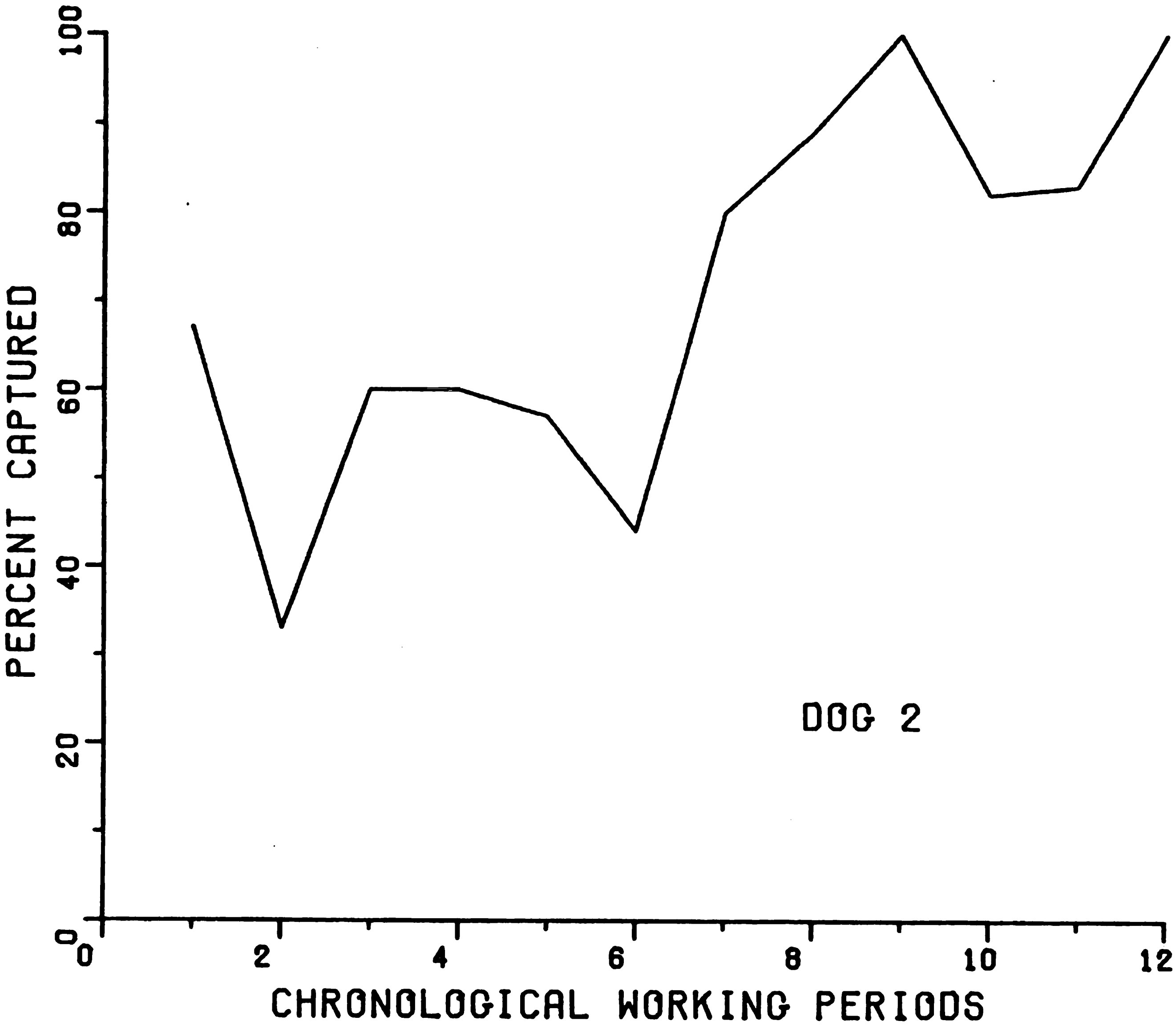

Figure 5. Learning rate

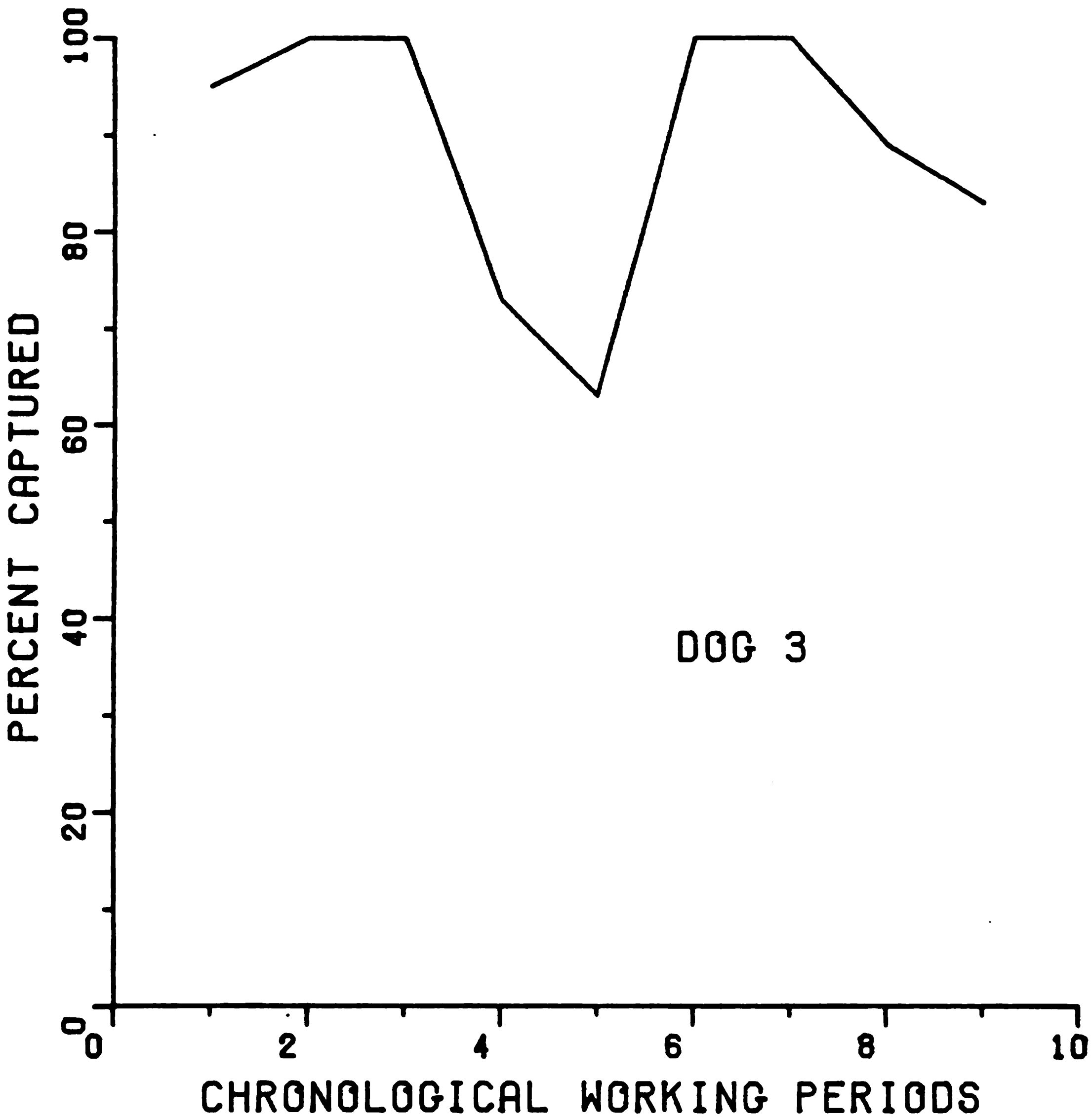

Figure 6. Learning rate

of egg masses discovered and "efficiency" as the rate of discovery, i.e., egg masses per minute.

The efficiency of each dog at varying densities was evaluated. The two variables (rate of capture and density) for each dog were fitted to the regression equation Y = a + bx (Tables 6 and 7).

Table 6. Rate of capture and density estimates - dog # 2

Rate of Capture (Number of Egg Masses per Minute)	Density (Egg Masses per ha.)
.09	100
.08	100
.09	100
.20	200
.15	300
.33	300
.33	300
.23	400
.42	600
.25	600
.50	600
.79	1100
.90	1900
1.45	1900
1.08	2000
1.71	3700

Table 7. Rate of capture and density estimates - dog # 3

Rate of Capture (Number of Egg Masses per Minute)	Density (Egg Masses per ha.)
.06	100
.07	100
.20	200
.10	200
.21	200
.10	300
.42	600
.44	800
.93	1300
1.16	2000
1.23	2200
1.67	3100
2.73	6100

The resultant curves were quite similar (Figures 7 and 8). Utilizing the two regression equations it was possible to make density estimate predictions from the rate of capture estimate (Table 8). These estimates will be incorporated in a later discussion concerning data collected when the dog (# 2) was allowed to search free of geographical constraints.

The two regression lines were compared using the covariance model: $Y_{ij} = {}_{i} + B_i X_{ij} + E_{ij}$ (Snedecor and Cochran 1974). The two lines were not significantly different at the = .05 level (Figure 9). The data was pooled (Table 9) and a single regression was produced (Figure 10). From this, density estimates were predicted from the pooled regression (Table 10).

Time Plots

In many areas where gypsy moth has been a recent introduction population levels seem to remain at very low levels for many years.

EGG MASSES PER HA.

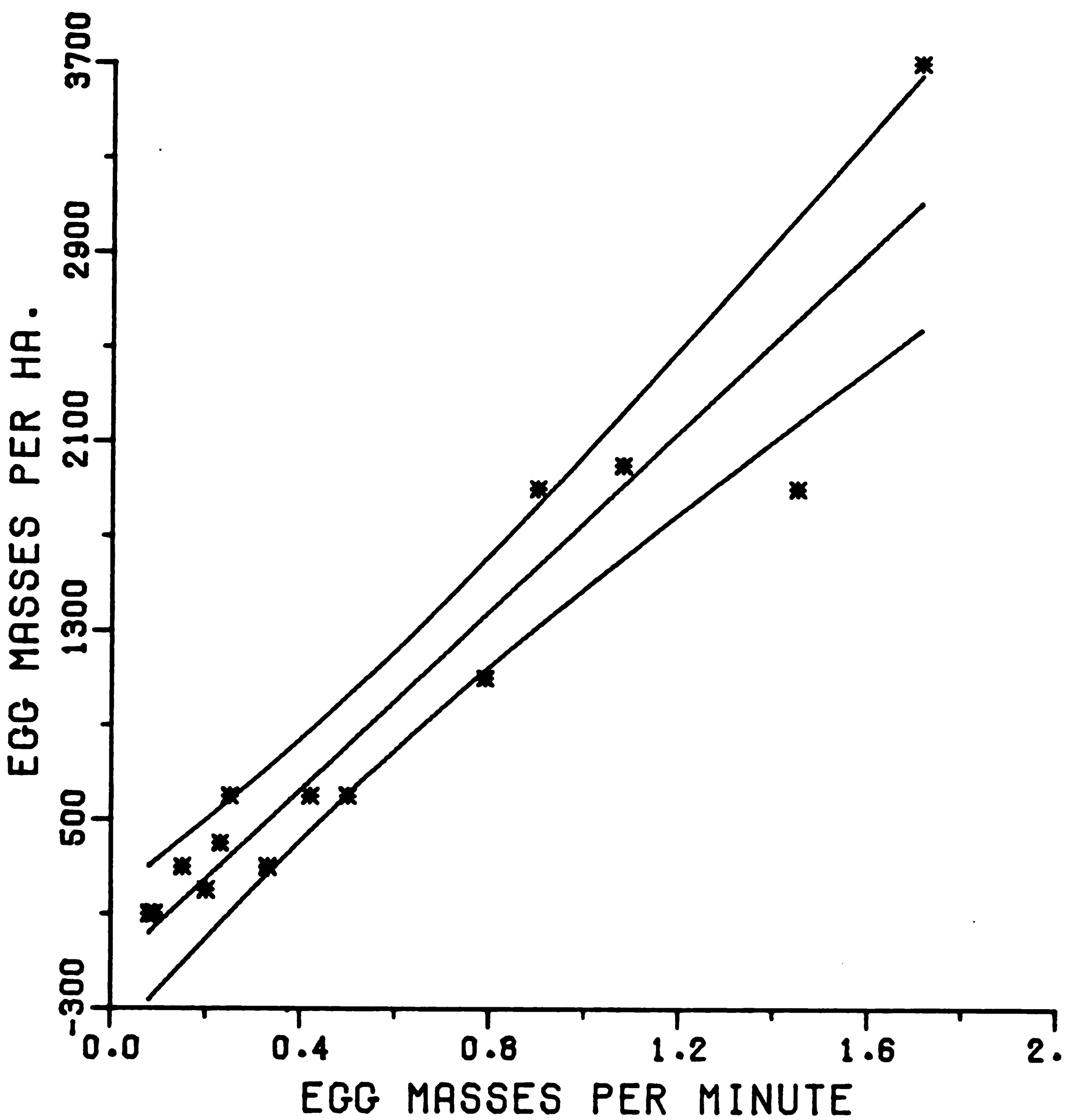

Figure 7. Rate of capture vs. density (dog #2)

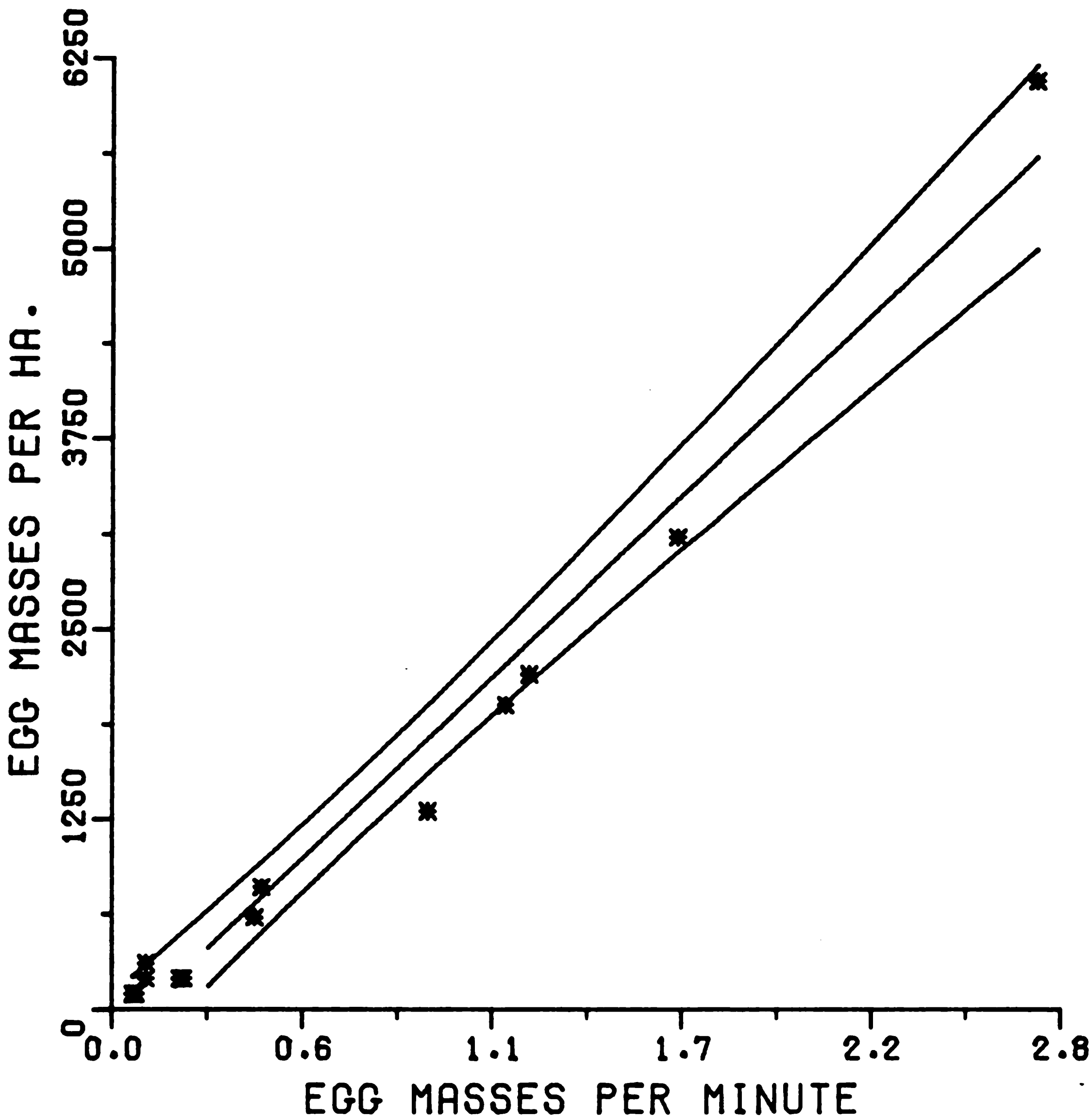

Figure 8. Rate of capture vs. density (dog #3)

Table 8. Estimating density from rate of capture (Y=A + BX)

Dog # 2 Density	Dog # 2 Rate of Capture	Dog # 3 Density	Dog # 3 Rate of Capture
37.8	0.1	14.4	0.1
227.9	0.2	234.0	0.2
418.1	0.3	453.6	0.3
608.3	0.4	673.2	0.4
798.4	0.5	892.8	0.5
988.6	0.6	1112.4	0.6
1178.7	0.7	1332.1	0.7
1368.8	0.8	1551.7	0.8
1559.0	0.9	1771.3	0.9
1749.1	1.0	1990.9	1.0
2699.9	1.5	3088.9	1.5
3050.6	2.0	4186.9	2.0
4601.3	2.5	5285.0	2.5
5552.0	3.0	6383.0	3.0
6502.7	3.5	7481.0	3.5
7453.5	4.0	8579.1	4.0

These incipient populations are many times quite diverse throughout a region but at levels that make them difficult to detect. In a management mode the ideal detection and sampling scheme for these regios would be one that allows the handler and the dog the freedom of movement to sample the greatest number of areas in the shortest possible time frame. To facilitate this it would be advantageous to the dog and handler to "free search" (dog and handler would not be constrained by geographical plots) an area. This sampling scheme would do away with plot markers, post-search verification, etc.

To test this, dog # 2 conducted searches in the general vicinity of plots of known densities (areas I-IV). Ten minutes was the time limit chosen for each search period. This time limit was chosen arbitrarily but it was felt, at that time, that the dog could search for this amount of time without any loss of efficiency. Eighty 10-minute searches were conducted. Eighteen of the searches resulted in no egg masses being discovered and, therefore, could not be analyzed. The remaining 62 are listed in Appendix D.

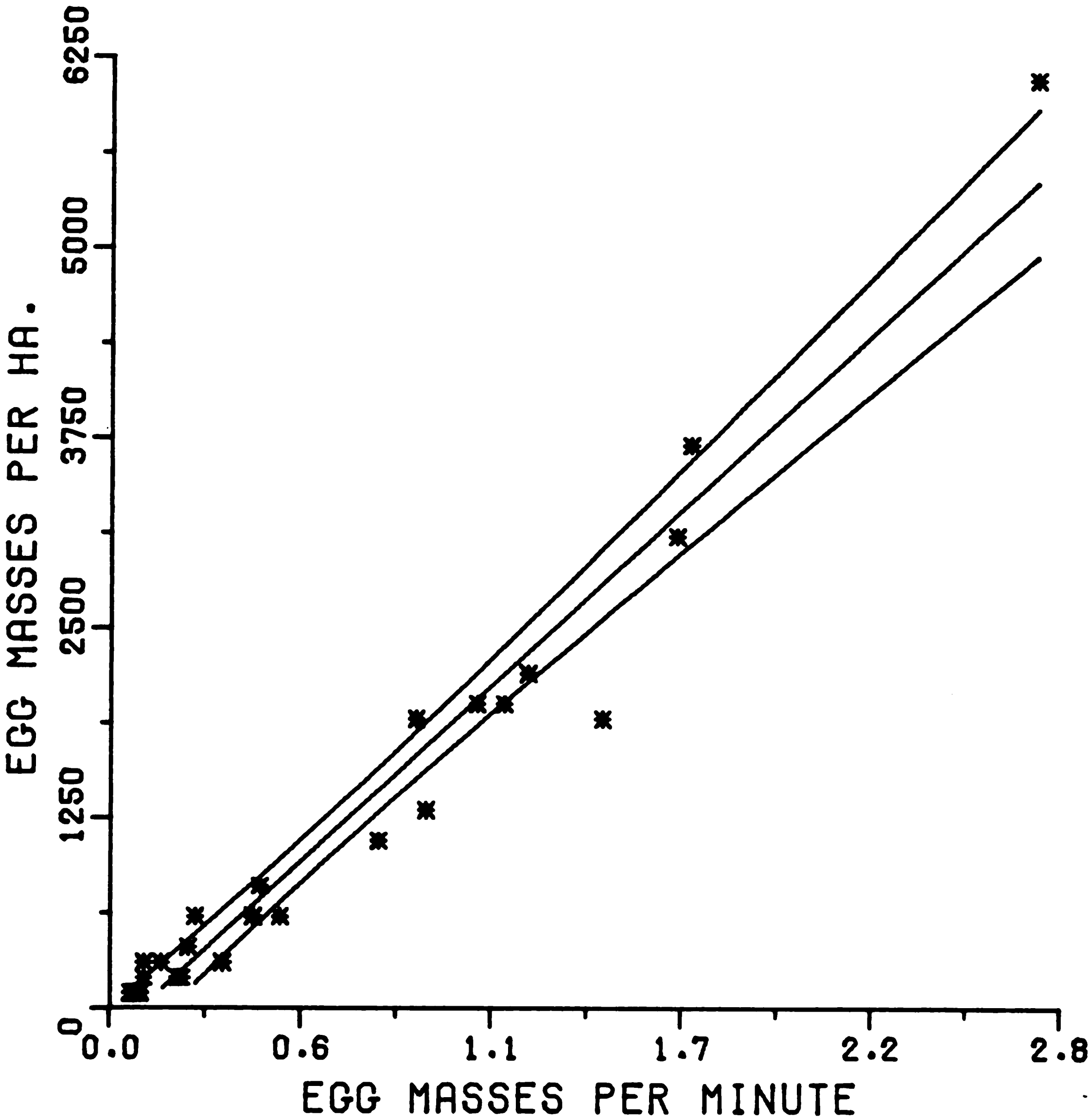

Figure 9. Rate of capture vs. density (dogs #2 and #3)

Table 9. Rate of capture and density estimates (Dog #2 and Dog #3)

Density (em/ha.)	Rate of Capture (em/min.)
400	0.23
600	0.42
1100	0.79
3700	1.71
1900	1.45
2000	1.08
1900	0.90
600	0.50
600	0.25
300	0.33
300	0.33
400	0.44
300	0.15
200	0.20
100	0.08
100	0.09
100	0.09
2200	1.23
1300	0.93
100	0.06
200	0.20
200	0.10
600	0.42
100	0.07
2000	1.16
3700	1.67
6100	2.73
800	0.44
300	0.10
200	0.21

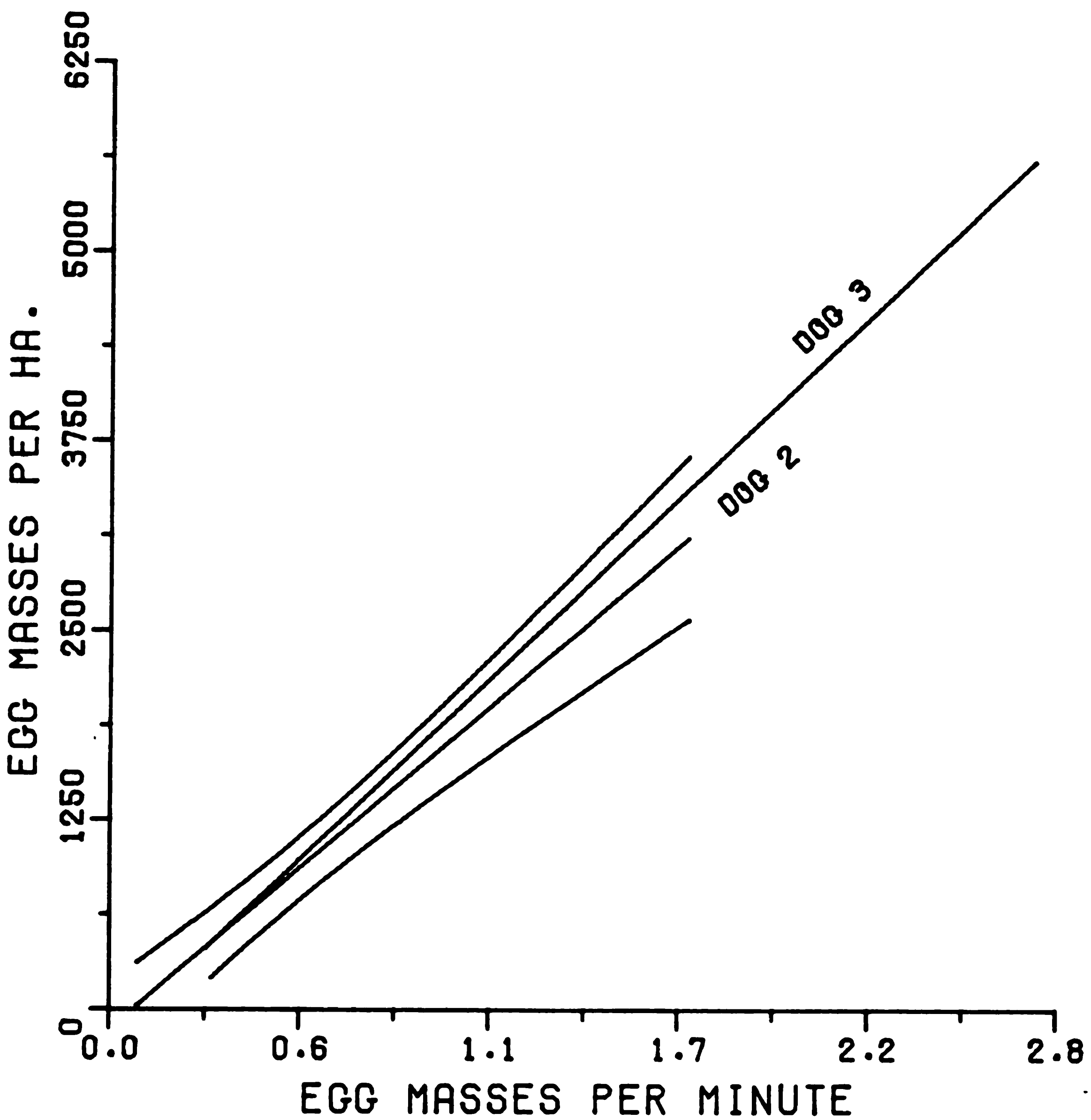

Figure 10. Comparison of regression lines (Dogs #2 and #3)

Table 10. Estimating density from rate of capture (Y= A + BX)

Density (em/ha.)	Rate of Capture (em/min.)
209.7	0.2
420.9	0.3
632.2	0.4
843.4	0.5
1054.7	0.6
1265.9	0.7
1477.1	0.8
1688.3	0.9
1899.6	1.0
2955.7	1.5
4011.8	2.0
5067.9	2.5
6124.1	3.0
7180.2	3.5
8236.4	4.0

Table 11. Timed search summary

Area	N	Plot Search (EM/ha.)	Timed Rate of Capture	Plot Rate of Capture	Predicted Density from RC	Predicted Density from Plot RC (Dog # 2)
I	18	570	.47	.52	456	836
II	20	2400	1.14	1.49	1950	2680
III	14	200	.48	.23	475	284
IV	10	470	.44	.42	684	646

The density estimate predicted by the regression equations for timed and plot 'rate of capture' (RC) brackets the density estimates of Areas I and II. Predicted density estimates for Areas II and IV are both high. What is most significant, however, is the closeness of the timed rate of capture (TRC) and the plot rate of capture (PRC). This indicates that with adjustments an accurate prediction model based on this type of data could be developed.

Climatic Factors

In an earlier discussion it was noted that the odor system of the egg mass was not quantifiable at that time. It was also suggested that the odor system was so subtle that the dog had to be within one to two meters of the egg mass in order to recognize its presence. Regardless of this, it was decided that in order to maximize the efficiency of the searching dog, it was important to have some understanding of how the unknown odor system was affected by the physical factors of the environment. Data was collected and analyzed concerning three basic climatic parameters: temperature, relative humidity, and wind speed.

The metabolic activity of an egg mass is affected by changes in temperature (Leonard 1972). Within limits, as the temperature increases so does the metabolic rate within each egg and vice versa. It seemed reasonable that increased metabolic activity plus the natural heating of the egg mass due to radiant energy would tend to increase the volatility of the gaseous molecules within the chorion of each egg in the cluster. If olfaction was linked in a functional manner to the volatility of these gases and there are no other contradictory forces, then olfaction should increase as daily temperatures increase.

Analysis of the data indicates no such relationship (Table 12) (Figure 11). This is also true for relative humidity (Table 12) (Figure 12) and wind speed (Table 12) (Figure 13).

Time of Day

It was observed in the field that odors were most distinctive early in the morning and at dusk. Geiger (1971) reported that this phenomenon is quite common during the warmer months. During a typical summer night a thermal inversion occurs. A layer of warm air is trapped near the ground. At sunrise this layer remains trapped for a period of time creating a stratified layer through which the odor of the egg mass is disseminated. Since most of the cooler temperatures were recorded early in the day it would seem that this inversion, when present, would be beneficial to the searching dog. Only a slight positive correlation could be shown to exist between time of day and success (Table 12) (Figure 13).

Table 12. Percentage of egg masses discovered vs. climatological conditions and time of day (Dog#2)

% Captured	Temperature (^{o}F)	Relative Humidity (%)	Wind Speed (m/min.)	Time of Day
50	68	90	100	0800
100	68	90	90	0900
100	75	70	105	1100
67	70	75	110	0900
100	80	60	90	0930
75	72	78	100	1100
67	82	85	90	1500
67	82	85	90	1300
80	70	90	350	1330
82	70	90	350	1400
97	70	90	350	1430
84	75	78	50	1030
90	52	75	450	1100
74	54	74	450	1130
100	55	70	450	0900
33	70	75	94	1000
67	70	75	97	1000
75	71	79	100	0800
33	71	79	96	0730
100	70	70	50	0815
100	54	100	50	0900

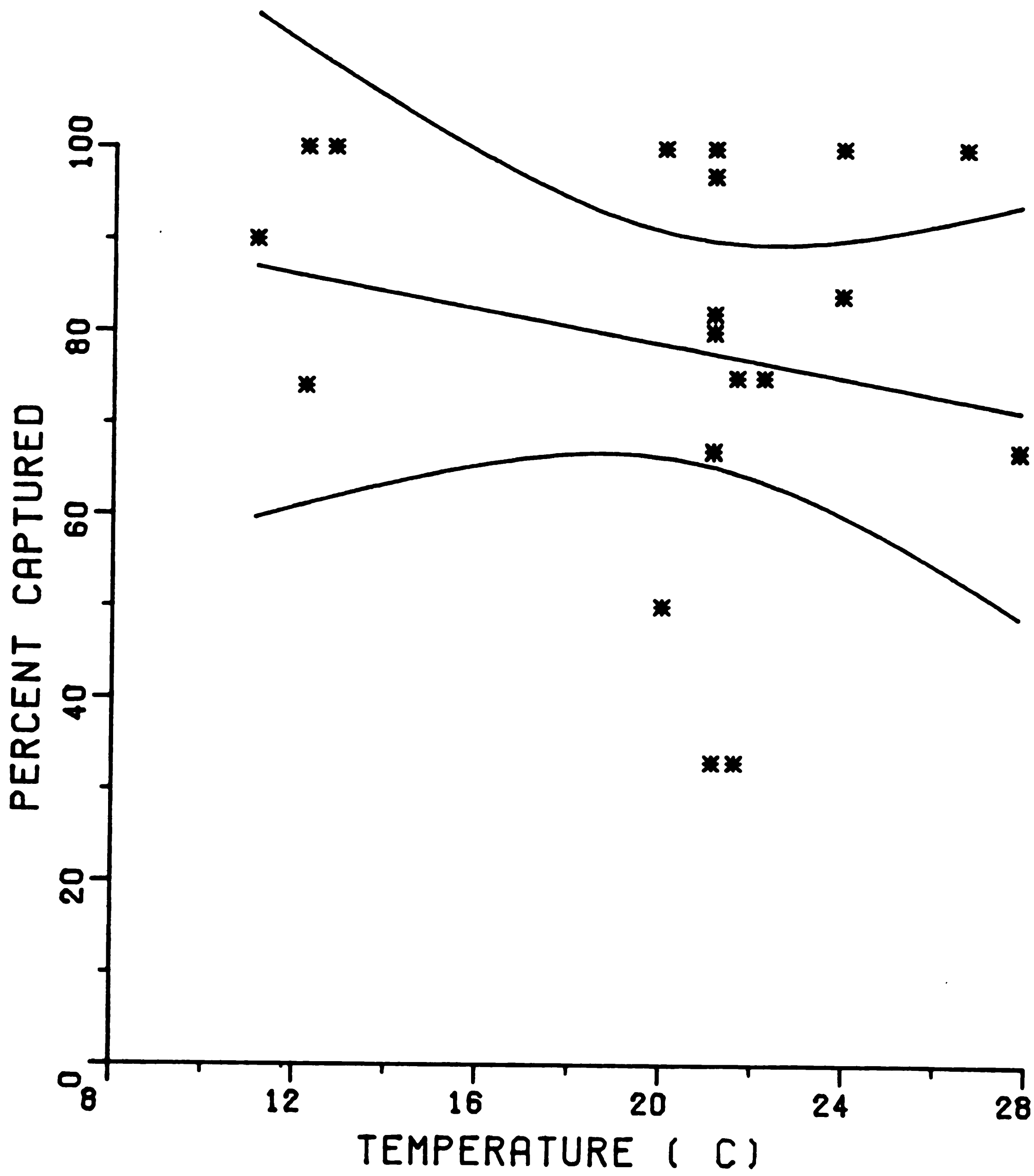

Figure 11. Temperature vs. percent captured (dog # 2)

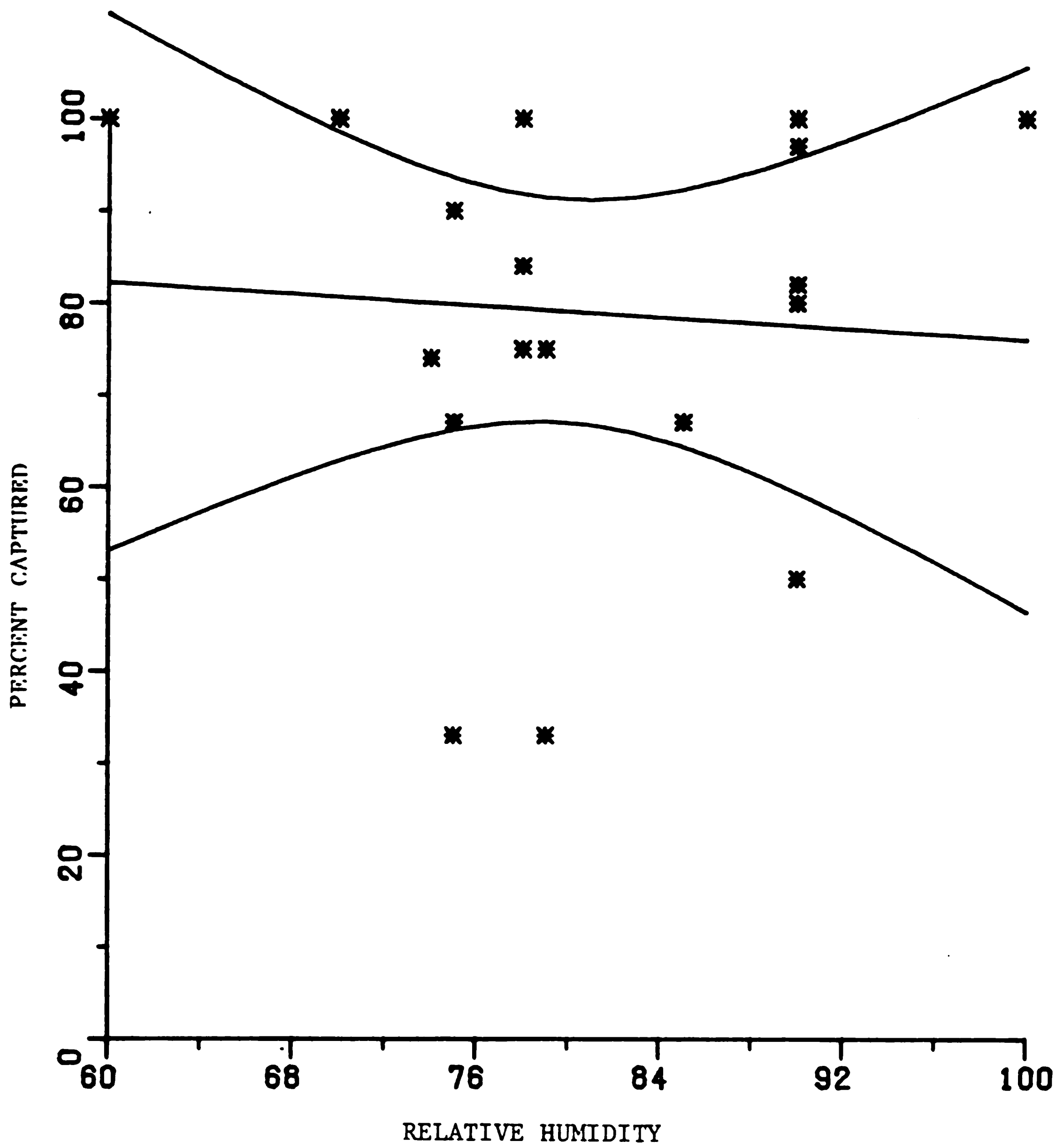

Figure 12. Relative humidity vs. percent captured (dog # 2)

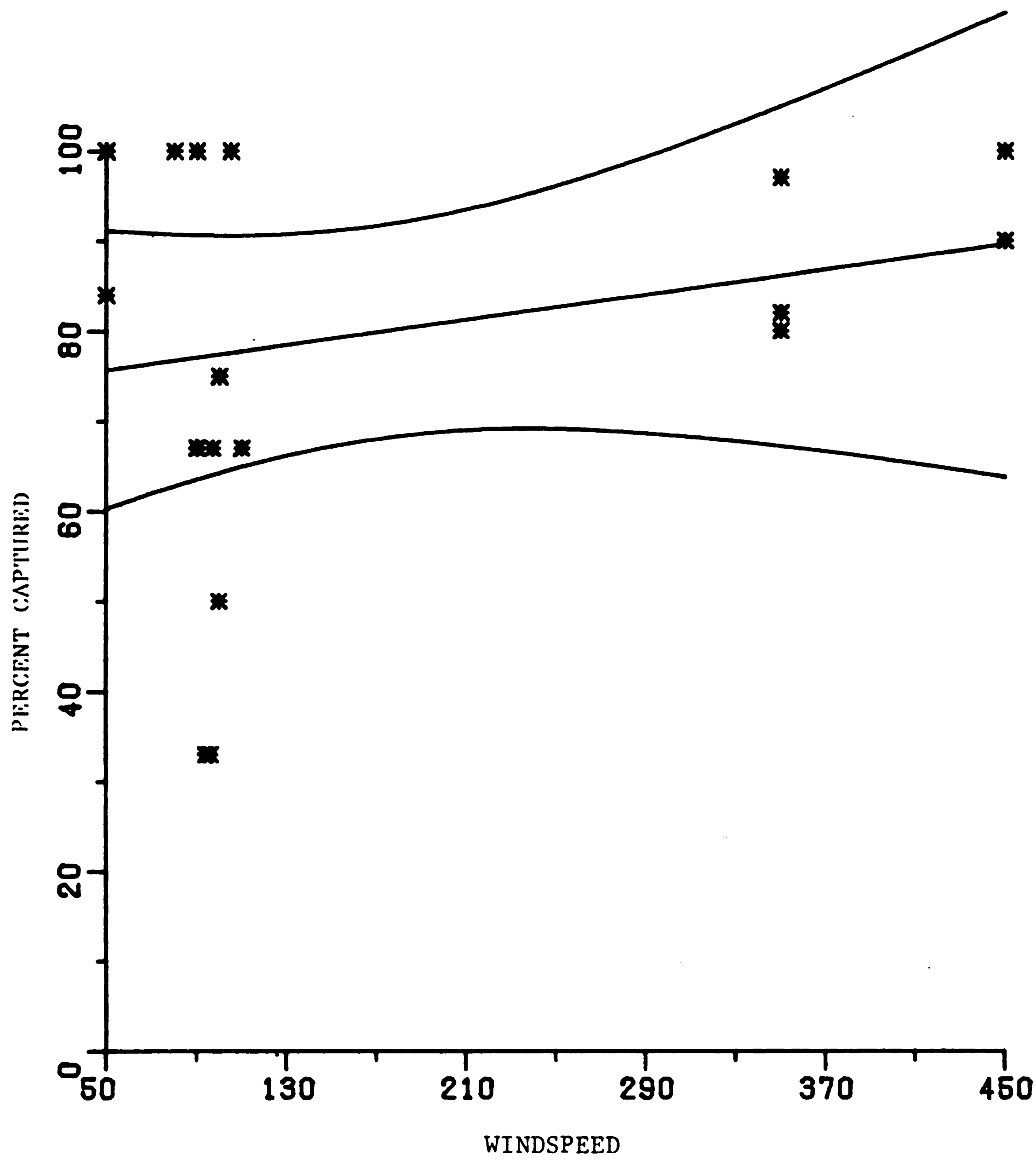

Figure 13. Windspeed vs. percent captured (dog # 2).

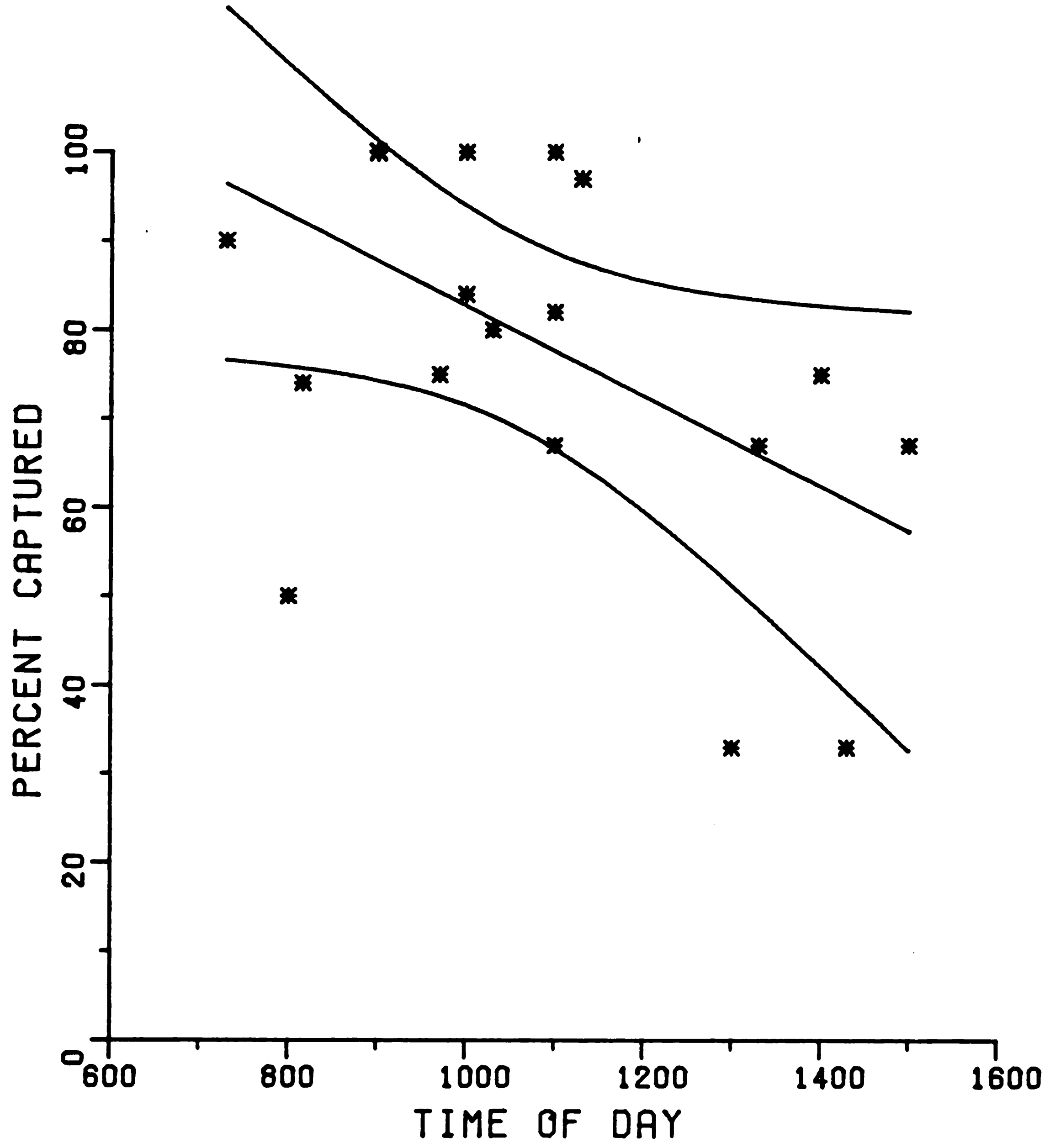

Figure 14. Time of day vs. percent captured (dog # 2).

Attractiveness of Live vs. Dead Egg Masses

The purpose of this experiment was to establish a standard of measure utilizing a known parameter of measurement; number of viable eggs per mass. This measure, however crude, would give future researchers a benchmark which could be utilized for comparison purposes until the technological tools became available to identify and characterize this odor complex. This experiment was conducted in Pennsylvania when the dog (# 2) was at peak efficiency and presumably at his peak sensitivity also.

Four levels of sensitivity were measured: 0, less than 50, 50 to 100, and more than 100 viable eggs. Three choices were offered the dog as in earlier experiments (one object containing eggs, two not containing eggs). The substrate used was oak bark flaps. As soon as the dog secured a bark flap with his mouth he was ordered to drop it and the procedure was repeated until the experiment was completed. The number of eggs offered was selected randomly.

The four size classes were tested statistically using the Chi-Square Test ($E^2 = \frac{(0-E)^2}{E}$) (Table 13). This test was utilized to analyze any significant differences between the observed (0) event (number of retrieved eggs) and the expected (E) event (retrieval of all eggs) within each size range. The Chi-Square Test showed significance at those populations greater than 50 eggs (Table 13).

Table 13. Detectability of live vs. dead egg masses

	Number of Viable Eggs/Mass			
	0	Less than 50	50-100	More than 100
Number of successful retrieves:	25	25	25	25
Parent success:	0	12	80	100
E:	25.0	19.4	1.0	0

Matrix Experiment

The training of domestic canines for locating, by olfaction, egg masses of the gypsy moth has been documented (Wallner and Ellis 1976). The purpose of this experiment was to test the quantitative characteristics that are common to all predator-prey relationships: functional and numerical responses to prey density. The other basic behavioral response associated with predation (functional response to predator density) could not be tested at this time.

Holling (1961) reported that of all the factors affecting predation, prey and predator density are the basic components since they are always present. It is the intent of this component of the study to explore the responses of the components of this system to the variables of input. By quantifying the responses of the searching dog to changes in prey density and time, this study will show the homology that exists with predator-prey relationships, artificial or natural. Methods and Materials- The area utilized was a 5 m x 5 m matrix consisting of 25 possible selections. Preliminary tests were conducted to determine what time parameters could be utilized to ensure that the dog (#2) could retrieve a baited substrate within an allotted time period and to determine what maximum time limits would be useful quantitatively. These conditions were imposed for two reasons: (1) Allowing the dog time to find at least one baited substrate at any density greater than zero required at least five seconds. Therefore, using a time parameter less than five seconds would be a moot exercise and could have deleterious effects on the animal (confusion). (2) If the dog would have been allowed time to retrieve all 25 possible selections the researchers believed that the animal could retrain itself to retrieve by sight since sight, not olfaction, could become the most efficient manner of search. Johnson (1975) observed similar behavioral phenomena while training dogs to locate gas line leaks in Ontario.

The odor system utliized in this experiment was an artifact of macerated egg masses in distilled water (see Training Manual). The egg mass solution was prepared in the same manner, at the same concentration and administered at the same volume (.5 ml) for the entire experiment. A new solution was prepared prior to each testing period. The substrates were .64 cm x 2.54 cm x 20.3 cm pine slats. For each trial 25 slats were used. The slats were arranged in a 5 m x 5 m matrix.

In each test 25 slats were placed on the described grid. The density of annointed slats varied from one per test (low density) to 25 per test (high density). Non-annointed slats comprised the remainder of the grid. During all trials the dog never retrieved a non-annointed slat.

All preparation of test matrices was completed out of the animals line of sight. All areas were prepared in advance of each testing period. Each test area was laid out in a grassy area free from visual obstacles that could alter the air flow within and between plots. The tests were conducted over a 10 day span that presented similar climatic conditions. The mean temperature was 7.2^{o}C with a range of from 5.2^{o}C to 10.0^{o}C. The average wind speed was 1.51 m/min. and the average daily relative humidity was 60%.

Each testing period consisted of 6 trials representing 6 different densities to be tested. The time parameter was chosen at random. The number of test periods completed each day was dictated by the stability of the climatic factors and the amount of available light. In all, 10 test periods for each time parameter were completed (50 test periods total).

The routine followed was consistent for each testing period. Each trial was initiated with the dog in a sit-stay position (see Training Manual) one meter from the test matrix on the downwind side. The timed interval included all activities from the instant the find-it command was issued until the animal left the matrix with a slat. At this time, the dog was rewarded and put into the sit-stay position. The timer was restarted at the reissue of the find-it command. The routine was repeated until one of two events transpired: the dog used up the allotted time or all the baits were retrieved. The reward component was not included in the timed period since this component is quite variable (see Qualitative Evaluation of the Search). The reward time component was, however, limited to a maximum of 20 seconds. Five time limits (90, 60, 30, 15, 5 seconds) and 5 densities (1, 2, 15, 20, 25) were evaluated with no replacement.

Results- Holling (1959) reported that the number of discs discovered by his blindfolded predator was a functional response to prey density. The curve that characterizes the searching dog (Figure 15) indicates that to a certain point in the search (especially evident within the larger time limits) the relationship between the number of retrieves and density is somewhat linear. As the time constraints become restrictive, the curve flattens showing the density dependent relationship.

In the Holling experiment, the doming of the curve was a functional response to prey density. The doming of the curve in the matrix experiment was the result of the cause and effect relationship. If the predators' density remains constant, the organism can remove only so many prey units from a given area within the allotted time. In the matrix experiment the insects' fecundity was replaced by a searching time limit. The causes were similar and the effects identical.

Discussion- Predation can be affected by many factors. Characteristics of the environment and behavior of the predator and prey can change the magnitude of the response but the form and shape of the search curve will remain intact. For example, Burnett (1958) found that the success of the parasitoid (*D. fuscipennis*) searching for sawfly cocoons was affected by temperature. In the matrix experiment the climatic factors were stable, therefore, only two factors could influence the magnitude of the functional expression: time and density. Keeping time constant a shift in the magnitude of the curve is explained as a function of density.

Efficiency of the searching dog was characterized earlier as the number of egg masses discovered per minute (rate of capture). Efficiency in the matrix experiment was defined as the ratio of useful energy delivered by a dynamic system to the energy applied to it. This is useful if it is translated to mean the ratio of the standard deviation of the dog's success rate to the mean number of successes (Coefficient of Variation). Multiplying this number by 100 gives a percentage representation of the variability of the observations about the mean ($CV = \frac{S \times 100}{\bar{X}}$). This method allows the researchers yet another way to evaluate the variability in populations (retrieves) that have different means (Sokal and Rohlf 1969).

In the matrix experiment significant variation occurred only within the 5 second time parameter and at the lowest density (1) of the 15 second time parameter. This was probably due to the large number of no retrieves (0).

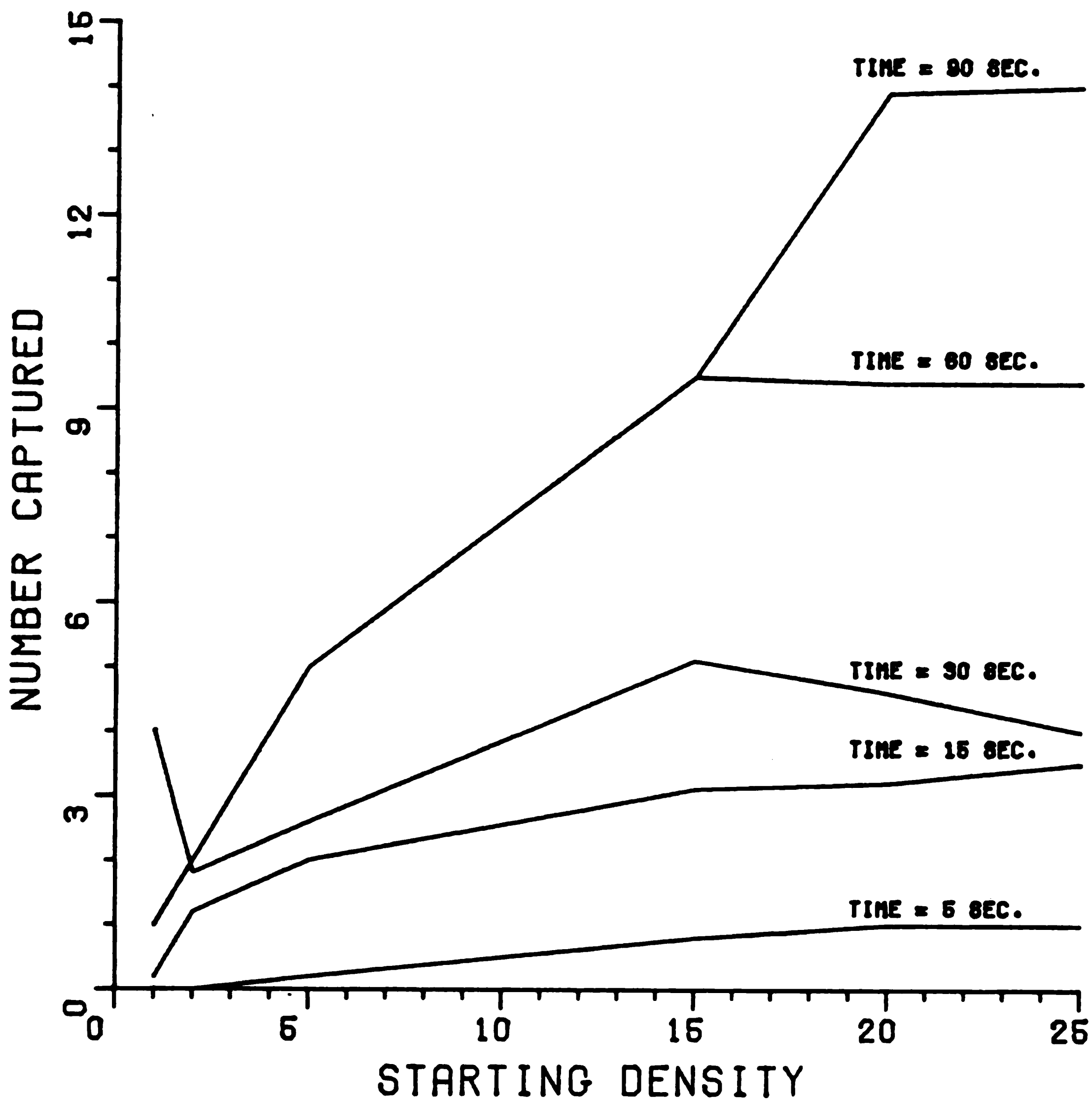

Figure 15. Matrix experiment (dog # 2).

DISCUSSION

As mans technology evolves towards the complex, so does his pursuit of an understanding of the ecological systems he studies. Many times, however, the answers to seemingly simple queries such as "How many?" and "Where are they?" cannot be dealt with effectively with the existing technology. A perplexing question indeed. This is certainly true with many insects, especially the gypsy moth.

Certain governmental agencies (e.g. APHIS) have historically been responsible for detecting, quarantining, and controlling (eradicating) new populations of gypsy moth as they occur in heretofore uninfested environs. This task has, more often than not, confounded these agencies because of their reliance upon techniques of detection and survey that have been developed in areas where 300 to 500 egg masses per acre were considered to be very low population densities.

This work was a feasibility study. I firmly believe that if a judicious approach is taken to develop this concept into a program that utilizes the dog and handler as a team, the possibilities for practical application are virtually endless (e.g., overwintering boll weevil adults, fire ants, cattle infested with screwworm, inspection at ports of entry, etc.). I believe just as strongly that if this technique is expedited and utilized without further research, a technological tool of boundless potential will be squandered and lost.

PART II

TRAINING MANUAL

PREFACE

A total of two years of intensive work was spent in developing the technology necessary to train a dog to detect egg masses of the female gypsy moth reliably. It is imperative that the reader understands that this portion of the thesis is merely a generalized outline of an "artform" that has taken many decades, if not centuries, to develop.

Research Animals Utilized in the Study

Three German shepherd males were utilized in this study. Dog # 1 was 12 months old; # 2 was nine months old. Neither dog had any previous training. The third dog was seven years old and was proficient in the areas of obedience, tracking, and utility.

Breed Selection

Dogs and men have been allied for thousands of years. One of the earliest recorded was canine companions to the pile drivers of Switzerland approximately 8,000 B.C. (Humphrey and Warner 1934). As the usefulness of the canids increased they became more specialized. Areas of specialization commonly depicted on potteries, frescoes and sculptures of past times show illustrations of dogs hunting, herding, and drawing draft.

The German shepherd was selected for this research for basically three reasons: the breed's relative intelligence, the history of olfactory excellence within the breed, and this breed seemed to possess the physique best suited for working long hours in habitat favorable to the gypsy moth.

German shepherds are the result of careful selective breeding. The ancestors of the present breed were the sheep herding stock common to northern and southern Germany in the nineteenth century.

Selection of the Research Dog

The selection of the proper dog is paramount for any project of this nature. During the early days of the study proper care was not taken in dog selection and the program suffered for it. Careful initial screening will exclude the protraction of the project due to lack of desirable traits of the research animal.

The candidate dog is screened in three areas: physical structure, temperament, and parasympathetic nervous system.

Physical Structure

Twenty-eight morphological points of the animal are examined for their suitability. They were graded on a pass-fail basis. Dog # 1 was not evaluated using the criteria of this examination. Dogs # 2 and # 3 met or exceeded each point. The list of 28 morphological characters examined was first considered by Ebeling (1927), and later revised by Humphrey (1934). The following list and corresponding explanations were prepared by Humphrey and revised by Ellis:

Ears - should be as long as the depth of the head (i.e., from the crown of the head to the bottom of the jaw). The ears should be actively testing sources of sounds about the animal.

Expression - The animal should be willing to meet your gaze. Look for an animal that seems to be neither too stern nor too timid.

Eyes - The dog's eyes should be dark in color. For reasons not yet known, dogs with light eyes (yellowish) tend to show poor temperament.

Upper Jaw - The shorter more compact jaw indicates German breeding. Long narrow jaws are typical of the American breeding. Select for the shorter jaw.

Lower Jaw - Should be proportional to the upper jaw. Select for the shorter more compact jaw for the same reasons mentioned above.

Teeth - Strong and white teeth indicate excellence of bone structure, present and past good health.

Neck - A long and well muscled neck are necessary for the constant shifting of the center of gravity encountered working.

Forechest - The broader and deeper the forechest the better adapted the animal will be to long hours of work.

Withers - Long and well developed withers indicate firm musculature and muscle attachment.

Scapula - An angle of 135° gives the greatest freedom of movement of the muscles of forward shoulder region.

Humerus - The humerus should be of sufficient length to allow for the placement of the legs well under the body.

Radius-Ulna - The angle of these bones must be angulated to allow the legs to be perpendicular to the ground.

Heel - Tendon structure should stand out clearly.

Pasterns - Of medium length, strong in appearance and at an angle of about 60° with the ground.

Forefeet - The forefeet should be medium to large in appearance. The pads should be thick and black.

Ribs - The ribs should be well sprung and leave the backbone at a sharp angle backward. This allows for the greatest increase of lung capacity.

<u>Chest Depth</u> - As deep as possible without being out of proportion to the rest of the body.

<u>Back</u> - The more straight backed the animal is the better. Hip displasic seems to be correlated with a sharp angulation (i.e., downward angle from front to back).

<u>Loin</u> - The loin should be strong and heavy in the lumbar region.

<u>Croup</u> - The longer the croup the greater the overall musculature of the dog.

<u>Tail</u> - The tail should be thick and low set. This is an indication of German breeding.

<u>Flank</u> - The flank should be deep and full. This indicates intestinal capacity. The greater the intestinal capacity the smaller the chance of distension.

<u>Pelvis-Femur</u> - The pelvis should be x-rayed to determine whether or not the animal is dispastic. Any degree of displasia will disqualify a candidate dog.

<u>Gaskin</u> - The gaskins should be prominent. This indicates a strong knee joint and sufficient tendon attachment.

<u>Hock</u> - The hock should be large and strong since it transmits the mechanical energy from the upper legs to the paws. Larger hocks are better suited for absorbing the impact of short stops and quick turns.

<u>Hind Feet</u> - The hind feet should be slightly smaller than the front feet (the weight carriers). The pads should be thick and black.

Power Line (from the loin to the hind paw) - The components of the power line should be proportional. No matter how impressive the individual units are if they are not in proportion to each other breakdown will occur.

Gait - The gait should be a fast floating trot. The animal that does not look labored when it is running will not expend as much energy working as the dog that does look labored.

Temperament Testing

Once a candidate dog has been deemed physically fit it is tested for temperament. Temperament is the type of mental reactions characteristic of the animal. This definition has been modified to be the mental reactions characteristic of a dog that best suits the needs of this research project. The four characteristics considered to be most important are fearlessness, aggressiveness, curiosity, and territoriality. A working dog must be fearless. Once it sets about a task it should act with a single-mindedness that will not allow anything to interrupt the completion of the task. A dog must be aggressive. It should be willing to search areas that could potentially compromise the animal's physical well being. A dog must be curious to the point of being meddlesome. This character is most often misinterpreted as hypertension and not tolerated. It should not only be tolerated but appreciated. It is the one character that is most easily channeled from a play activity to a work activity.

These three characters are all elements in the expression of territoriality. The fearlessness of a dog is the measure of the magnitude of the territorial defense. At one extreme is immediate flight and at the other is defending the territory until defeat becomes obvious. Wolves rarely, if ever, fight to the death over a territorial dispute. The same holds true for their domesticated descendents.

Aggressiveness measures to some extent the size of the territory that the danid is willing to defend. The dog not only establishes the limits of the territorial boundaries by urine and fecal marks, but maintains these boundaries by periodic patrol. The animal's territorial area is a function of aggressiveness.

Curiosity is a function of intelligence. Curiosity also seems to be a by-product of fearlessness and aggressiveness. A dog that scores high in these two areas seems to be more curious than the canid that does not. Curiosity in canines ultimately seems to involve the animal in situations that can compromise its physical well being. The more timid, less aggressive animal seems to lose its curiosity more rapidly than the canid that is willing to put itself into potentially dangerous situations.

The assumption was made that those cahracters reflected in the animal's defense of a territory would later be reflected in working. These assumptions seemed resonable at the time and proved to be valid throughout the training period and field experiments. It must be remembered, however, that the situation the animal experienced for this test was artificial and does not dictate absolutely how the same animal would respond towards the invasion of its natural territory.

Temperament Test

Konrad Lorenz (1953) evaluated a dog's temperament by the animal's behavior towards other animals, especially of the same species. This was an intuitive process on Lorenz's part. He evaluated the reactions of the subject, basing his evaluations on a lifetime of studying animal behavior, and recorded his observations of specific events in a popularized journalistic fashion. The testing procedure chosen for this study is an objective analysis of the dog's reaction to a series of three events: passive approach (the presence of an intruder visible to the canid but not an immediate threat), the aggressive approach of the intruder to the extreme limits of the territory, and the aggressive invasion of the dog's territory by a hostile intruder.

This test has been used by many trainers of working dogs implemented in a number of ways. The specific technique adopted in this research program was refined and popularized by Glen Johnson to screen candidate animals.

Methods and Materials

The candidate canid is taken to a predetermined location by the handler or the dog's closest human companion. The location, preferably an open field, must meet two requirements: (1) It must have a tree or artifact of sufficient size to which the dog can be tethered and held securely, and (2) The area must have a field of visibility from the point of tether of not less than fifty meters in all directions (Figure 15). As soon as the animal is taken to this location it is tethered. It should be done in such a fashion that will allow the dog to move freely with a radius of movement of from three to four meters. The line used to secure the dog should be of such construction that an enraged dog cannot lunge and break the line or chew through it. The material best suited was found to be plastic coated, heavy gauge steel wire. The attachment of the restraining line to the tree should be at chest height. This allows the dog freedom of movement without becoming entangled in the line. The attachment of the tether to the dog is very important. A leather collar is required. A lunging dog cannot hurt himself or slip a collar of this type. A choke collar can cut a lunging dog and it is also quite easy for a dog to slip out of this type of restraint.

Once the dog is secured the handler leaves the dog and moves out of sight. The dog is left alone for a minimum of 15 minutes. This length of time is generally sufficient to get the dog used to the fact that he is alone and that there is no immediate prospect of the handler's return. Once the animal has been deserted, it will bark, lunge at the line, and generally carry on in an attempt to summon its master. This usually does not last more than five to ten minutes. Next the dog will try to free himself from the restraining line. This usually lasts an additional five minutes. Finally the dog will resign himself to its entrapment and either lie or sit down. It is at this point that the test can begin. Occasionally, an animal will go into shock. At this point the test should stop. The handler of the dog should return to the animal immediately. The dog should be calmed with soothing language. Do not release the animal until its behavior has returned to normal. The dog has shown characters that are undesirable and will be elaborated upon in a later section. -- See "Parasympathetic nervous reaction test and evaluation."

The temperament test involves two people, an observer and an intruder. The observer is concealed out of sight of the dog and perpendicular to the line of vision AB (Figure 16). The observer watches the animal's head only, noting changes in facial expression. The observer should be in position before the dog is tethered. He should be well concealed and far enough from the animal as to not draw attention to his position. A distance of 50 meters is usually adequate. At this distance binoculars aid the evaluation.

The intruder should be someone unfamiliar to the animal. The intruder should act and dress in such a manner that the dog will interpret his physical appearance and his mannerisms as aggressive and hostile. Many animals before engaging in battle contort themselves to give the appearance of greater body size. The intruder is instructed to do this also. The physical contortions are substituted by an oversized coat and hat giving the intruder greater size both horizontally and vertically. The aggressor is also armed with a weapon. The weapon used in this project was a 3' x 3/4" dowel wrapped with burlap and bound with 1/2" masking tape. Most canines are very vocal before they engage in a fight. The barking not only calls attention to their presence but also serves as a warning to potential invaders. Therefore, the intruder is instructed to be vocal also.

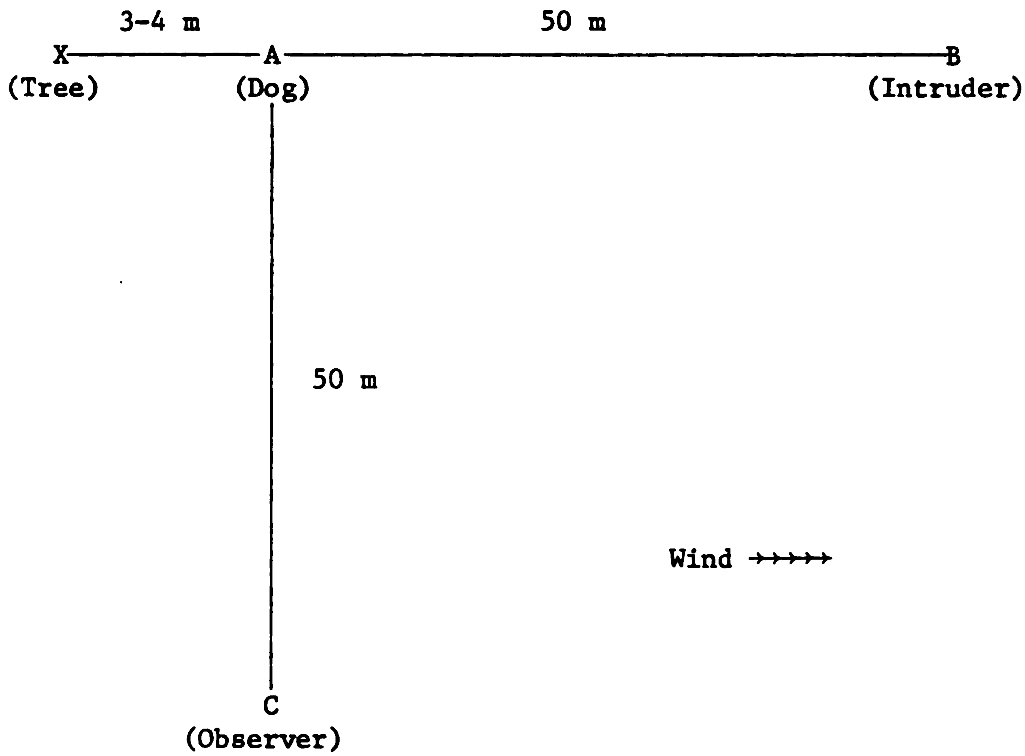

Figure 16. Temperament testing

The test consists of three parts: the passive approach, the aggressive approach, and the assault.

Step # 1. Passive approach. The intruder is concealed from the animal, downwind at a distance of approximately 50 meters. The intruder initiates the passive approach by walking from the point of concealment, unarmed, towards the dog. The intruder advances towards the dog until he is sure that the animal is aware of his presence. Once the dog has given some overt sign (watching, barking, or attempted flight) relaying its awareness of the presence of the intruder, the man retreats immediately to the point of concealment and steps from sight.

If the animal attempted to flee the test is over and the dog has failed the temperament test. Any further aggravation can only bring physical/mental harm to the animal. The ideal reaction is the animal sitting, laying, or standing, and watching the approaching intruder. Many times the animal will commence barking when it notices the approaching form. The concealed observer must determine whether the dog is barking to belie its presence or is responding out of fear. When a dog barks out of fear there is a contraction of the facial muscles resulting in the tightening of the skin areas around the eyes and muzzle. This is easily detected by noting whether the dog is baring its teeth when barking. A dog that is not frightened will bark out of the front of its muzzle and subsequently not bare many teeth in the process. Other noticeable signs of distress include raised hackles on the back of the dog's neck and position of the ears. A dog showing fear will lay the ears back in a position perpendicular to the plane of the top of the head.

Step # 2. Aggressive approach. The intruder should approach the dog waving the weapon above his head. The aggressor should walk at a brisk gait stopping every 10 paces. He should be very vocal and very loud. Upon nearing the animal it is very important that the intruder be aware of the length of the tether. The intruder does not want to provoke an attack at this time. The final step of the aggressive approach should be approximately two meters from the end of the tether. At this point the aggressor should retreat to a point midway between the blind and the dog, thus positioning himself for the assault.

Two desired reactions are favorable. If the dog is very young (five to seven months) it is quite possible that the animal will simply watch the approaching intruder with a quizzical expression. In this instance the observer will note the animal standing, sitting, or laying with its head erect but tilting it slightly to one side. The important factor is that the canid show no outward signs of fear. The desired reaction with the more mature dogs is the preparation for defense of its territory and itself. This is initiated by the animal being very vocal. Occasionally the dog will retreat to the point of tether and measure a perimeter that it is confident of defending. In effect, the canid will take its position and attempt to relay the message that it is reluctant but ready to engage in battle. The observer should not only note facial expressions but also the tone of the warning bark. A dog barking out of fear will sound high pitched and the vocal notes will be short and stacatto. The dog that is not showing fear will sound deep and full throated and the vocal notes will be rhythmically even.

Step # 3. The assault. The assault is initiated from the position assumed at the commencement of the aggressive approach. The approach is identical to step # 2 with one exception: the neutral zone that was established between the dog and the intruder in the aggressive approach is violated during this step. The intruder should attack the canid with the weapon held well away from the body. The primary function of the weapon is not offensive beyond the point of harassment. The secondary function of the weapon is defensive, but not in the sense one would expect. The dog should focus its attack on the weapon since the weapon is the immediate source of danger. The weapon should be held in such a fashion that it will always be between the intruder's body and the dog. If the dog should decide to attack, the weapon will be offered to the animal. When the animal grabs the weapon it should be relinquished to him immediately. If the weapon is not released immediately the dog's focus of attention will quickly shift to what is attached to the weapon.

Once the canid has either attacked or attempted to flee, the test has ended and the intruder should retreat to a position outside of the range of the animal. The animal may be startled by the attack and initially retreat. This is not a sign of cowardice but is usually evidence of the dog's inexperience in combat. The aggressor should continue the assault and force the dog to make the decision to stand its ground or to flee. This phenomenon is characteristic of younger dogs.

When the test has been terminated the dog's owner and/or handler should be summoned. The owner should soothe the dog using quieting gestures and language. Once the dog has been quieted the intruder should approach the dog and handler in full view of both. The intruder should then shed his coat and hat slowly. Once it has become apparent that the dog is at ease, the handler should free the animal from his restraints and let the dog approach the aggressor. The aggressor should imitate the gestures and language of the handler. The temperament test is now completed.

Parasympathetic Nervous Reaction Test

A working dog in the field encounters many diversions. Its discipline and training exclude these events from becoming more than a momentary distraction. Certain events do occur, however, that will surprise the animal (flushing a bird, discharge of a firearm, etc.) and have an effect on the canid's automatic nervous system, more specifically, its parasympathetic nervous system.

Hoar (1966) describes the parasympathetic nervous system as that part of the automatic nervous system which is made up of two groups of nerves arising in the cranial and sacral regions respectively, and their auxiliaries and which among its functions is the constriction of pupils, dilating of blood vessels, slowing of the heart, and increasing of the activity of the glands and digestive and reproductive organs.

Langley (1921) describes the specialization of the parasympathetic nervous system. The sacral groups are those nerves responsible for the excitation of the viseral region of the body.

A working dog should have a high threshold of excitability, i.e., its parasympathetic nervous system, with respect to cholinergic excitation, should be slow to engage and quick to recover. As was described earlier in the text with reference to dog breeding, show qualities and intelligence are diametrically opposed. The same seems to be true with respect to the stability of the parasympathetic nervous system. The greater the inbreeding and breeding for specific phenotypes the lower the threshold of excitability.

When an action occurs that stimulates the sacral nerve group of the parasympathetic nervous system one of the physiological responses is a tremor in some muscles. This is a parasympathetic effect caused by activated cholinergic nerves. The reaction can be detected by pressing the hand gently against the animal's flank (anterior to the pelvic girdle and posterior to the last costa).

The parasympathetic nervous reaction test can be administered at any time. In the total evaluation sequence the test was conducted immediately after the temperament test. The test requires two people. The only material requirement is a handgun and blank ammunition. The handgun should be .32 calibre or larger. Blank ammunition of smaller calibres is not desirous due to lack of audibility.

One person holds the animal while the other fires several rounds of blank ammunition into the air in rapid succession. This is best accomplished by the holder facing the dog away from the individual firing the handgun. The holder grasps the dog by the collar while placing the free hand on the flank.

The desired reaction is either no tremor or a tremor lasting a few seconds. If the tremor persists longer than 10 seconds, experience has shown that it will last for several minutes at the minimum. In this case the animal has failed the test.

Training

An important behavioral factor to be considered when training a dog for working, whether it be for herding sheep or detecting life stages of the gypsy moth, is the development and reinforcement of the expression of fidelity. Lorenz (1953) describes fidelity as arising from two roots. First and foremost are the dog's maternal ties. The strength and longevity of these ties directly relate to the devotion of the mother to her pup. The strength and longevity of the ties are directly proportional to the length of time a domestic canine retains its youthful characteristics. The second origin of fidelity arises from the loyalty of the canid to its pack and pack leader. If the dog is acquired as a pup the handler must be prepared to accept both roles. In one instance he must be the patient, compassionate mother and in another instance he must assume the role of the dominant pack leader. It is imperative that the handler be aware of the importance of this role during all of the training sequences. When the dog is disciplined the handler must know the source of the necessary action. If the dog has made a mistake in the training routine the corrective action must be tempered with maternal compassion. If the dog's action is a refusal, and, therefore, a challenge to the pack dominance, the discipline must be a quick and decisive reprisal.

The handler must be aware that those who are indirectly related to the training program, but are associated directly with the developing dog, are in effect members of the pack. Confusion has surfaced in this program concerning the relationship of the wives and children of the trainer and his associates with that of the dog being trained. Women and children by their very nature readily accept the maternal role but most often will not answer a challenge from the dog. This submission makes them subordinate to the pup in the pack order. Overt signs of this are the pup's willingness to play and to be pampered but absolute rejection of dominate gestures by associated women and children. By advancing himself in the pecking order beyond other members of the pack, the maturing pup can experience being dominant. This new position in the pack hierarchy is a stabilizing influence. Even though the pup, especially a male pup, is expected to challenge the pack leader for supremacy, some of the animal's malicious energy is directed towards subordinate pack members and away from the handler and is a benefit to the program as a whole. It is my belief that a solid understanding of the concept of fidelity and all of the subsequent ramifications is very important.

Once the handler has solidified the pack relationship and assumed the role of pack leader, more energy and time can be spent in the actual training procedures. The length of time needed to accomplish this task is due in large part to the age of the animal when it is acquired. The ideal is to obtain the dog as soon as it is weaned. If this is not possible it is best to acquire the animal when it is most impressionable. With domestic canines this stage of development usually occurs at five months of age.

Once the expression of fidelity has been solidified the formal training can begin. The training of a dog to perform certain olfactory tasks is the direct result of regimentation and concentration on the handler's part. If the handler is to be successful he must remember four basic concepts: (1) Obedience is the fundamental building block of all training. Obedience training enables the handler to control the actions of the dog, both during the training period and later in the field. Obedience training also gives the handler and the dog a vehicle of communication. Even though communication in this instance is mostly one way, there is at least a clear link between the two organisms; (2) Successful training is the result of successful planning. For the most part training is 75% planning and 25% repetition. The good trainer can anticipate failure and be able to correct it quickly or avert it altogether; (3) The dog is always right. Once the handler is well into various aspects of the training regimes, he will realize that when the dog has elicited an improper response it is usually due to erroneous input by the handler. More times than not the animal will be responding properly to an improper stimulus; and (4) Always repeat the previous exercise. Even though at times the dog will seem to be as smart as a human, it is still a dog. Before starting a new exercise go back and repeat the previous one. This will give the handler and the dog a chance to start an exercise on a successful note.

Obedience Training

The first area of formal training is obedience training. The procedures followed are a collation of ideas on the subject. Several suggested methods were considered and tried. The methodology decided upon was a combination of the methods used by Strickland (1969) and routines used by Johnson (1975) in the training of tracking dogs. The general term applied to this type of training is the "reward, no reward system." The basic difference between this type of training and most of the other common techniques is that this technique does not emphasize physical harassment. It is believed by many dog trainers that the reward, no reward system is slower, but strengthens fidelity.

This section will outline the obedience training utilized in this research project, an explanation of the training vocabulary, the desired response to each training component, and a brief summation of the procedures applied.

Training Vocabulary

The dog elicits the proper response to the verbal command by associating the desired response to the spoken command. The vocabulary used by the handler is the vehicle carrying the message from the man to the dog.

COMMAND

The command is always given in a clear strong voice. The handler must be consistent in his delivery. It is very easy to incorporate emotion into the verbal command that changes the command to a plea. All commands are prefaced with the dog's name. Most working dogs have one syllable names to ease the verbalization of an oral command.

All verbal commands should be taught with associated hand signals. The handler will encounter situations that will favor one type of command over the other.

REWARD

The verbal reward should always be associated with the successful completion of a commanded task, not just a good try. The timing of the reward is the subject of another section. The use of the verbal reward is used by itself, with a food reward, with physical contact, or any combination of the three. When physical contact is utilized for reward (i.e., scratching, stroking, or petting) one rule should be remembered. Never pat the dog on the head. An overzealous pat can be and usually is taken for a reprimand.

REPRIMAND

The verbal reprimand is issued in a tone of voice that is harsh and condescending. Never use the dog's name when scolding. The dog's name should be used only in a positive nature (i.e., a command or a reward). Sometimes the dog will not respond to verbal condemantion. Stronger measures should be taken but these measures do not include striking the animal.

The handler should grasp the dog by the neck on either side of the head where the head and neck meet. The dog can then be lifted off the ground until the muzzle of the animal is at the same level as the handler's face. When dog and handler are face to face the animal is admonished again. At the same time the dog is shaken vigorously. When the scolding has been completed the dog is dropped and verbally admonished again. This procedure does not harm the dog physically. This is a very effective procedure since it seems to humiliate the animal. This is very similar to how a dominant male will discipline a pack subordinate, especially a juvenile.

Obedience training is divided into two categories, on-lead and off-lead training.

Sit-Stay

The desired response of this component is the dog sitting next to the handler for one minute or until commanded to do otherwise.

Training procedure: The animal is fitted with a collar made of chrome plated steel or stainless steel. The construction of the collar allows one end to move freely through a ring fitted on the opposite end. The term commonly applied to this type of collar is "choke collar." To the choke collar is attached a six-foot leather leash, commonly called a "lead."

This training component is made up of two subcomponents: sitting and staying. The procedure is completed when both subcomponents have been mastered in that order.

With the leashed dog standing at the handler's left, the command "sit" is issued in a firm but not loud voice. At the same time, while holding the leash firmly behind the animal with the right hand, steady, firm, downward pressure is applied to the animal's haunches with the left hand. This movement by the handler must be timed exactly with the spoken command. As soon as the animal's haunches touch the ground, the handler drops the lead, faces the dog and rewards him. The reward component consists of three subcomponents: oral acclamation, physical embrace, and a food reward. The entire sequence is repeated until the dog is sitting on command only.

The length of time spent in each training session is a subjective matter. The handler must keep in mind that all dogs are not the same and, therefore, the time taken to master each new skill varies accordingly.

The stay component of this sequence is initiated by commanding the dog to sit at the handler's left. Holding the lead behind the dog's head with the left hand, the handler gives the command to "stay." Simultaneously the right hand is swung across the handler's body from right to left with the palm of the hand open towards the dog. The horizontal movement is terminated when the dog's nose is tapped with the open hand. The handler then moves one pace forward. If the dog follows, it is treated with indifference, returned to the sitting position, and the procedure is repeated. If the animal elicits the improper response after several trials, an alternative method should be employed. This consists of following the same procedure until the handler is about to move away from the animal. At this point the handler should tighten the lead and as he moves away from the dog restrain the animal by applying pressure to the lead in the opposite direction. This alternative method should be alternated with the original method. As soon as the animal starts to exhibit reluctance to move forward, progress has been made and the animal should be rewarded. As the animal responds to the tap on the nose and the verbal command, either can be eliminated. The handler will be in situations in the field where the ease of one command supersedes the use of the other. It is good to alternate the use of either form to solidify the meaning of both in the dog's memory. The handler can deem the "stay" exercise successful when he can command the dog to "stay" and move about freely for three minutes without the animal leaving the commanded position.

Heeling

The desired response of this component is the dog moving at the handler's left side, at the same gait, neither in front of or behind the handler.

Training procedure: The animal is put into the sit-stay position. The handler gives the command "heel." Simultaneously he moves forward, leading with his right foot. If the dog stays in the sitting position the handler should give the lead a firm tug as he moves away from the dog. If the dog moves ahead of the handler, the handler should respond with a tug in the opposite direction. Each time a corrective action is taken the command should be repeated.

Heeling is perhaps the easiest of all the skills for the dog to master. This is partially due to the fact that walking next to its master is agreeable to the dog and also the handler has the benefit of a more disciplined animal to work with than in the previous exercise.

Down-Stay

The desired response of this component is the animal laying on the ground with the proper body posture and remaining in that posture until commanded to do otherwise. The proper posture is the animal laying on its stomach with the pads of the hind paws touching the ground and the front legs extended forward of the body with those pads also touching the ground.

Training procedure: The animal is put into a sit-stay position. The handler faces the animal and gives the command "down." Simultaneously the handler's left hand with a tightened grip on the lead underneath the animal's chin jerks the lead downward. At the same time the right hand with the palm of the hand facing down is extended upward to a position above the handler's head. A soon as the animal is in the down position the handler should reward the dog. The dog will signal the handler when it is beginning to understand the meaning of the command. The animal will begin to go down a split second before the handler jerks down on the lead. At this time the handler can use the verbal and hand command exclusively. All hand commands should be exaggerated to avoid confusion on the dog's part.

Come-on-Command

The desired response of this component is the dog moving on command from a sit-stay or a down-stay position to the handler's side.

Training procedure: The animal is put into a sit-stay position. Holding the end of the lead the handler moves to a position in front of the dog approximatley six feet from the dog (the extended length of the lead). The handler than gives the command "come." Simultaneously, he gives the lead a slight, but firm, tug towards him. At the same time the handler moves his right hand in a beckoning motion towards himself. As soon as the animal reaches the handler, the dog is guided by the lead around the handler clockwise and returned to the sit-stay position. The dog is then rewarded.

The completion of this routine is the end of the on-lead portion of the obedience training. Before commencing the off-lead routines, the on-lead skills should be practiced until the handler is satisfied that the dog will accomplish the skills without error.

Three dogs were utilized in this research project. Dogs # 1 and # 2 were obedience trained utilizing these procedures. Training time for both the on-lead and off-lead routines differed significantly between the two animals. Dog # 1 required four weeks of training and dog # 2 required less than two weeks to learn and refine these skills.

Off-Lead

Sit-Stay

The desired response of this component is the dog remaining in the sit-stay position for an extended period of time while the handler moves about freely.

Training procedure: The animal is put into the sit-stay position. The handler then leaves the animal and walks around the dog in a random fashion, but never moves more than two paces from the animal. The handler then moves to a position two paces in front of the animal and faces the dog. The handler pauses and gives the "come" command both verbally and with gesture. If at any time the animal leaves the sit-stay position prior to the come command, the handler should quickly grab the animal with both hands (described earlier) and verbally scold the animal. The dog should then be immediately returned to the sit-stay position and the procedure repeated. After each successful exercise of the routine the animal is rewarded. Each succeeding exercise should have a pause longer than the preceeding one until the handler can move freely around the dog for an extended period of time (three to five minutes).

Down-Stay

The desired response of this component and the training procedure followed for this routine is exactly the same as the sit-stay routine just described.

Heeling

The desired response of this component is the dog moving at the handler's side, at the same gait, neither in front of or behind the handler.

Training procedure: The procedure followed is the same as the on-lead complement. Once the dog becomes proficient at walking at the handler's side the pace should alternately be speeded up and slowed down.

Come-on-Command

The desired response of this component is the same as the on-lead component except that the animal is summoned from different distances and out of sight of the handler. The training is primarily reward for success and verbal condemnation for mistakes. The distance factor eliminates the opportunity to physically correct mistakes since corrections are only effective when done immediately following the dog's error. At this point in training the animal has reached a point that verbal corrections are sufficient.

Retrieve

Free Retrieve

For this research scent discrimination is defined as the dog's ability to identify, capture, and retrieve objects or organisms by olfaction only.

The desired response of this component is the dog searching for, identifying, and retrieving objects treated with a specific scent.

Since disparlure could be applied to different objects at known concentrations it was ideal for use in scent discrimination training. It was also felt that should the female contaminate egg masses with its pheromone this would aid the canine in locating egg masses if they were trained to respond to the pheromone as well as the egg mass.

The materials used for retireval should meet the following requirements: (1) The objects should be of different compositions; (2) Should be objects that are easily thrown a great distance; (3) The objects should be easy for the dog to retrieve; and (4) They should be objects that do not irritate the animal's mouth. The objects used in this exercise were sticks, rubber balls, and tin cans. Prior to each training exercise the objects to be retrieved were treated with 1000 ug of disparlure. When manipulating the objects to be retrieved the handler should wear a sterilized rubber glove on his throwing hand. This is done to prevent the odor of the handler from being imparted on the object. The non-throwing hand was not protected since this hand was kept free to reward the animal. As an extra precaution the handler manipulated the objects with sterilized 6" stainless steel forceps.

Training procedure: The dog is put into a sit-stay position. The handler using the protected hand tosses the "bait" (disparlure-treated object) into tall grass, shrubbery, etc., out of sight of the dog. As soon as the object comes to earth the command "find it" is issued. At the same time the handler points in the direction of the bait while taking a step in that direction. The dog will be anxious to pursue the bait. With constant repetition of the associated verbal and hand signals, the animal will soon associate the two with the searching activity. Following each successful retrieval the dog is rewarded and the object is discarded. When the dog successfully retrieves 40 objects the dog is considered proficient and this training sequence has been completed.

Forced Retrieve

The desired response of this component is the dog retrieving objects on command that have been placed on the ground. While this procedure may seem to be redundant, it transforms the retrieval from a play activity to a work exercise and is an essential component of the training regime. It should be expected that this exercise will be met by a great amount of resistance on the dog's part. In the case of dog # 2, 36 hours were required to make the transition.

Training procedure: The dog is put into a sit-stay position. With his right hand the handler presents to the dog a wooden dowel or stick (8" x 1/2" is ideal). The stick is presented in the following manner. The stick is held firmly in the right hand. It is then brought to a position 1/4" from the dog's muzzle. At this time the command "take it" is issued. If the dog takes the stick a reward is warranted. If the dog refuses the stick the handler will then "brush" the dog's incisors (a rapid up-and-down motion against the incisors). It is at this point that an impasse will be reached. Experience has shown that the greater the retrieving instinct the greater the resistance to accepting the presented object. The training exercise now becomes a test of will. If the handler becomes discouraged and concedes, the dog has won. If this is allowed to happen the handler will from that point on be subordinate to the animal. This will be one of the last serious tests of pack dominance.

Eventually out of fatigue the animal will accept the stick. The next presentation is made at the same distance from the muzzle but half way to the ground. This presentation puts the dog in the position of making the initial retrieval response on his own.

A successful routine includes acceptance of the stick at the height presented and all heights previously attempted. The distance of the presentation from the ground is halved until the dog picks the stick from the ground without hesitation. At this point the stick is moved one pace in front of the dog. After each successful retrieve the distance is doubled until the animal is successful at 16 paces. At various times throughout the exercise complete regression will occur. This must be expected to occur. At some unpredictable point in the training the dog's will will be broken and the impasse will be breached. From this point onward, the animal will perform the task flawlessly. In the case of dog # 2, 35 of the 36 hours spent in this training exercise were spent getting the animal to the point of picking the stick up from the ground.

Quartering

The desired response of this component is the dog systematically searching a given area respondent to directional commands (both verbal and hand signals).

This training sequence signals the end of the fundamental training and the beginning of the training procedures that lead directly to the finished product. This training sequence also introduces new problems. The handler will not be expected to make behavioral corrections at long range. A responsive animal is imperative. If the previous training exercises have been successful no problems should be encountered for these reasons. If the dog is less than totally responsive, repeat the fundamental training exercises necessary to correct the shortcomings. The most seasoned of working dogs must occasionally be recycled for review of fundamental skills.

The principles involved in teaching a dog to quarter are simplistic in nature. They are made even more so by further subdivision of the basic elements into their components.

Training procedure: The dog is put into a sit-stay position. With the wind prevailing from the handler's left he moves away from the dog. At 10 paces the handler stops and positions a "flag" (1/2" x 5' wooden dowel with a 2' length of colored flagging ribbon attached to the top end). The handler places the bait at the base of the flag and returns to the dog's side (Figure 17-A). The dog is commanded to "find it" and rewarded when the bait is retrieved.

Next the bait is positioned not at the flag but three paces in the upwind direction (Figure 17-B). The routine which is followed when placing this bait will be the same for all the following quartering exercises. The handler walks to the flag, touches the base of the flag but does not deposit a bait. The handler then executes a 90 degree turn in the appropriate direction, takes three paces and deposits the bait on the ground. He returns following the same route taken to the spot, stopping at the flag to again simulate placement, and finally returning to the dog's side. The command "find it" is issued and the animal is dispatched. If the dog moves towards the bait instead of the flag, return the animal to the starting position immediately, and repeat the first half of the placement (to the flag only). Normally the dog will proceed to the flag. Upon reaching the flag the dog will usually look towards the handler "momentarily" when the animal discovers there is no bait at the flag. At this time the handler points in the upwind direction and reissues the "find it" command. In the early trials it is also advisable to step in the same direction to exaggerate the hand signal. After several repetitions the dog will begin to associate the hand signals with the direction of the undiscovered bait. When the dog and handler become comfortable and success is consecutive the bait placement is increased to 10 paces (Figure 17-C).

The process is then mirrored (inverted so the prevailing wind moves from right to left) and the procedures are repeated (Figure 17). Finally the two routines are married (Figure 17-F,G). This routine differs from the previous ones in that after placement of the bait the handler returns to the flag and continues for 10 paces beyond and simulates a bait replacement. The handler follows the prescribed route back to the dog's side.

The dog is dispatched. Upon reaching the flag the animal is commanded to search in the direction opposite the bait. After the animal has searched for several strides in that direction it is then commanded to reverse directions and the bait is retrieved. The procedure outlined earlier and represented in Figure 17 should be substituted freely throughout these exercises.

It is impossible to estimate the number of repetitions necessary to accomplish the desired behavior response of this training component. So much of the training is reliant upon the level of communication that exists between trainer and dog. The handler should be at the point in his "training" where he intuitively makes slight alterations in the procedure to expedite the sequence.

When the animal is quartering routinely it is time to introduce the animal plot configuration to be used in the field work. For this research two types of searching patterns were developed (Wallner and Ellis 1976): area plots and time plots. The area plots are .01 ha.

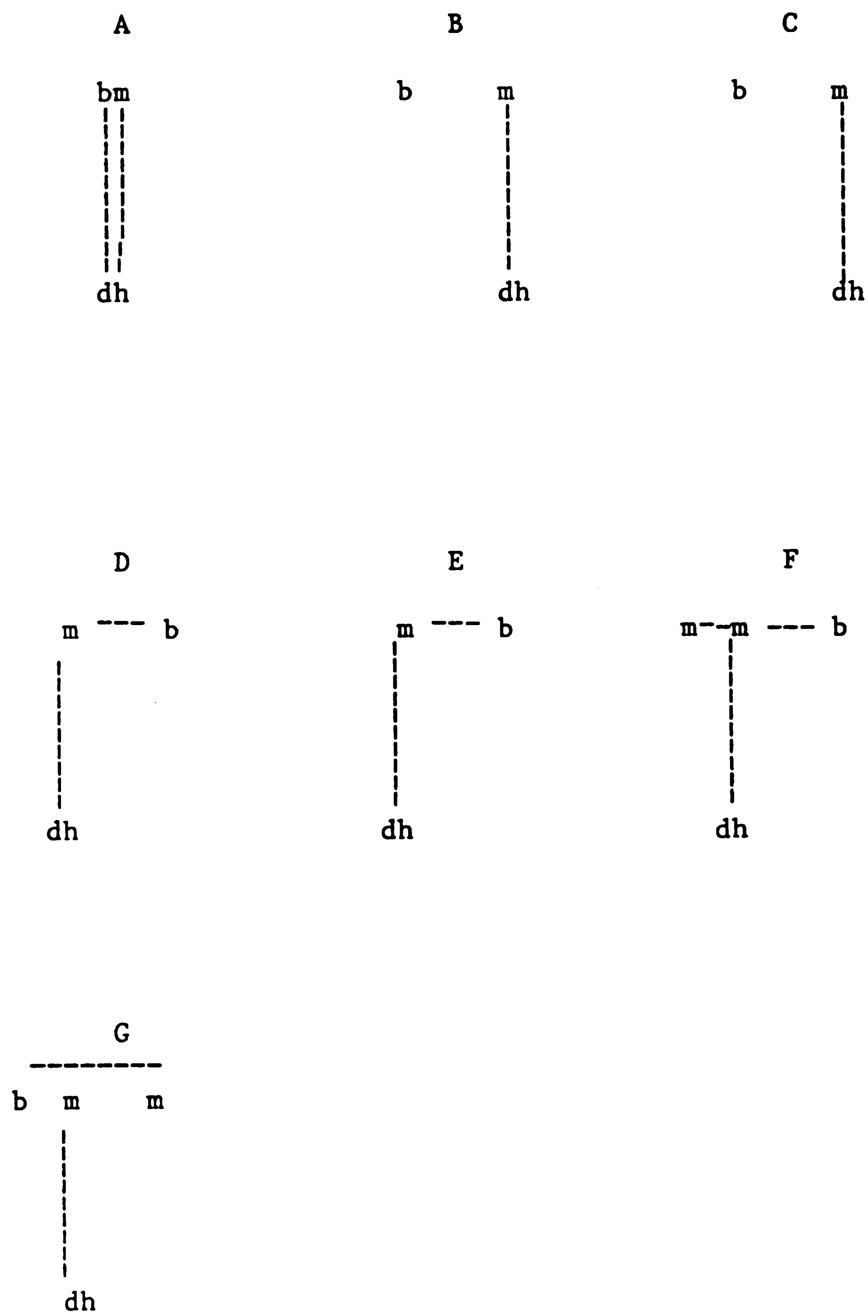

Figure 17. Quartering

in size (square plots approximately 34' x 34'). Each corner is marked by a flag. The manner of search is depicted in Figure 16. The time plots differ only in that there are no geographical boundaries, but the animal is limited to 10 minutes of searching time.

Egg Mass Olfaction

The desired response of this component is a dog that can detect by olfaction naturally-occurring gypsy moth egg masses.

Teaching a dog to discriminate for the odor of a gypsy moth egg mass is basically a twofold task. The dog must first learn to detect the odor system. This is best accomplished by concentrating the scent and teaching the animal to scent discriminate for it. When this has been accomplished the animal must learn to discern this odor system as it is presented naturally. The entire process entails four steps and like the other training routines one step is built upon the preceding one.

The concentration of the odor system is accomplished by grinding egg masses with mortar and pestle and putting the pulverized egg masses into solution with distilled water. Fifty egg masses to 100 cc of HOH seemed to be a satisfactory ratio to work with. The resultant solution has an odor detectable by human olfaction. The odor is quite similar to trout roe.

<u>Training Sequence</u>

Scent discrimination: The dog is put into a sit-stay position. Approximately 10 paces in front of the dog the handler places four like artifacts (sticks, tin cans, stones, etc.). The four objects are placed one meter apart in a 1 x 4 matrix configuration. On each of the objects 10 ml of egg mass solution (EMS) are dispensed. The handler returns to the dog and the "find it" command is issued. After each successful retrieve the dog is rewarded and the retrieved stick is discarded. This exercise is repeated until three consecutive successful repetitions have been recorded. The process is repeated with three of the four sticks being treated, then two, and finally one. When the dog attempts to retrieve an untreated object the handler issues a firm reprimand, "no," and follows with the command "find it."

When the animal is proven proficient the solution is halved in volume. The process is repeated until the animal is proficient at one drop (0.05 ml) of EMS.

Egg Mass Solution Plus Egg Mass on Substrate

The same 1 x 4 matrix is presented to the dog with the exception that one of the four objects has an egg mass on it. The egg mass is treated with a drop of EMS. Proficiency is again three consecutive successes.

Egg Mass Plus Substrate Only

The same procedure is followed but the drop of EMS has been eliminated.

Egg Mass Plus Substrate Positioned in a 0.05 Ha Plot

A 0.05 ha. plot is selected and flagged at the corners. The plot must meet one other requirement; at least one naturally-occurring egg mass must be observed within the plot within one meter of the ground.

The egg mass plus substrate is positioned within the plot. The dog is then commanded to search the plot until either the positioned egg mass or the naturally-occurring egg mass is found. This phase of the training is complete when the dog is finding the positioned and naturally-occurring egg mass.

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APPENDIX A

CLIMATOLOGICAL AND TEMPORAL DATA (AREA SEARCHES)

APPENDIX A: CLIMATOLOGICAL AND TEMPORAL DATA (AREA SEARCHES)

Dog No.	Area/Plot	Date	Time of Day	Temperature (°F)	R.H. (%)	Wind (ft./min.)
2	IV/1	8-16-75	0800	68	90	100
2	IV/2	8-16-75	0900	68	90	90
2	IV/3	8-16-75	1040	70	85	80
2	IV/4	8-17-75	1100	75	70	105
2	IV/5	8-17-75	1200	78	60	80
2	IV/9	8-20-75	0900	80	60	90
2	I/4	8-22-75	0900	72	78	100
2	I/6	8-22-75	1000	82	85	90
2	I/8	8-22-75	1100	82	85	90
2	I/10	8-22-75	1500	82	85	90
2	II/14	8-22-75	1030	70	90	350
2	II/15	8-22-75	1100	70	90	350
2	II/16	8-22-75	1130	70	90	350
2	II/17	8-24-75	1000	75	78	50
2	II/18	9-3-75	0730	52	75	450
2	II/19	9-3-75	0815	54	74	450

Dog No.	Area/Plot	Date	Time of Day	Temperature (°F)	R.H. (%)	Wind (ft./min.)
2	II/20	9-3-75	0900	55	70	450
2	III/21	8-21-75	1200	68	75	90
2	III/22	8-21-75	1300	70	75	94
2	III/23	8-21-75	1330	70	75	97
2	III/24	8-21-75	1400	71	79	100
2	III/25	8-21-75	1430	71	79	96
2	III/26	8-23-75	0900	70	70	>50
2	III/27	8-23-75	0930	70	70	>50
2	III/28	9-1-75	1300	56	100 (Rain)	>50
2	III/29	9-2-75	0800	54	100 (Rain)	>50
2	III/30	9-2-75	1000	57	100 (Rain)	>50
3	IV/5	8-21-75	1530	70	75	110
3	IV/6	8-21-75	0800	70	70	110
3	IV/7	8-21-75	0830	70	70	120
3	IV/8	8-21-75	0900	72	70	100
3	IV/10	8-21-75	1000	74	68	90

Dog No.	Area/Plot	Date	Time of Day	Temperature (°F)	R.H. (%)	Wind (ft./min.)
3	I/1	8-22-75	0900	72	78	100
3	I/2	8-22-75	0930	72	78	100
3	I/3	8-22-75	1000	72	78	90
3	I/5	8-22-75	1030	72	78	>50
3	I/7	8-22-75	1100	82	85	90
3	I/9	8-22-75	1500	82	85	90
3	II/11	8-22-75	0800	65	90	350
3	II/12	8-22-75	0830	68	90	350
3	II/13	8-22-75	1200	80	90	350
3	III/22	8-21-75	1300	70	75	94
3	III/23	8-21-75	1330	70	75	97
3	III/24	8-21-75	1400	71	79	100
3	III/25	8-21-75	1430	71	79	96

APPENDIX B

EGG MASS CAPTURE DATA (AREA SEARCHES)

APPENDIX B: EGG MASS CAPTURE DATA (AREA SEARCHES)

Dog No.	Area/Plot	Date	Elapsed Time (sec)	No. of Egg Masses	Rate of Capture (E.M./min.)
2	IV/1	8-16-75	219	1	---
2	IV/1	8-16-75	187	1	.30
2	IV/2	8-16-75	288	1	---
2	IV/2	8-16-75	229	1	.23
2	IV/3	8-16-75	---	0	---
2	IV/4	8-17-75	214	1	.28
2	IV/5	8-17-75	---	0	---
2	IV/9	8-20-75	132	1	---
2	IV/9	8-20-75	269	1	.30
2	I/4	8-22-75	250	1	---
2	I/4	8-22-75	320	1	---
2	I/4	8-22-75	102	1	.27
2	I/6	8-22-75	---	0	---
2	I/8	8-22-75	512	1	.12
2	I/10	8-22-75	181	1	---
2	I/10	8-22-75	107	1	.42

Dog No.	Area/Plot	Date	Elapsed Time (sec)	No. of Egg Masses	Rate of Capture (E.M./min.)
2	II/14	8-22-75	41	1	---
2	II/14	8-22-75	259	2	---
2	II/14	8-22-75	60	2	---
2	II/14	8-22-75	70	1	---
2	II/14	8-22-75	31	1	---
2	II/14	8-22-75	29	1	.98
2	II/15	8-22-75	21	1	---
2	II/15	8-22-75	30	2	---
2	II/15	8-22-75	99	1	---
2	II/15	8-22-75	48	1	---
2	II/15	8-22-75	29	1	---
2	II/15	8-22-75	233	1	.98
2	II/16	8-22-75	41	1	---
2	II/16	8-22-75	35	1	---
2	II/16	8-22-75	54	5	---
2	II/16	8-22-75	36	1	---
2	II/16	8-22-75	74	1	---

Dog No.	Area/Plot	Date	Elapsed Time (sec)	No. of Egg Masses	Rate of Capture (E.M./min.)
2	II/16	8-22-75	41	5	---
2	II/16	8-22-75	36	2	---
2	II/16	8-22-75	24	2	---
2	II/16	8-22-75	57	2	---
2	II/16	8-22-75	68	1	---
2	II/16	8-22-75	64	1	---
2	II/16	8-22-75	171	2	---
2	II/16	8-22-75	84	1	---
2	II/16	8-22-75	130	1	---
2	II/16	8-22-75	11	1	---
2	II/16	8-22-75	8	1	---
2	II/16	8-22-75	31	2	---
2	II/16	8-22-75	31	2	---
2	II/16	8-22-75	24	1	---
2	II/16	8-22-75	16	1	---
2	II/16	8-22-75	59	1	---
2	II/16	8-22-75	11	1	1.96

Dog No.	Area/Plot	Date	Elapsed Time (sec)	No. of Egg Masses	Rate of Capture (E.M./min.)
2	II/17	8-24-75	34	1	---
2	II/17	8-24-75	10	2	---
2	II/17	8-24-75	198	1	---
2	II/17	8-24-75	28	1	---
2	II/17	8-24-75	95	1	---
2	II/17	8-24-75	26	1	---
2	II/17	8-24-75	11	1	---
2	II/17	8-24-75	16	1	---
2	II/17	8-24-75	8	1	---
2	II/17	8-24-75	22	3	---
2	II/17	8-24-75	29	1	---
2	II/17	8-24-75	61	1	---
2	II/17	8-24-75	60	1	1.61
2	II/18	9-3-75	102	2	---
2	II/18	9-3-75	14	1	---
2	II/18	9-3-75	15	1	---
2	II/18	9-3-75	109	2	---

Dog No.	Area/Plot	Date	Elapsed Time (sec)	No. of Egg Masses	Rate of Capture (E.M./min.)
2	II/18	9-3-75	58	1	---
2	II/18	9-3-75	122	1	---
2	II/18	9-3-75	185	1	---
2	II/18	9-3-75	48	2	---
2	II/18	9-3-75	97	2	---
2	II/18	9-3-75	30	2	---
2	II/18	9-3-75	26	1	---
2	II/18	9-3-75	184	2	1.09
2	II/19	9-3-75	93	1	---
2	II/19	9-3-75	367	1	---
2	II/19	9-3-75	45	2	---
2	II/19	9-3-75	40	1	---
2	II/19	9-3-75	55	3	---
2	II/19	9-3-75	25	3	---
2	II/19	9-3-75	16	3	1.32
2	II/20	9-3-75	64	1	---
2	II/20	9-3-75	71	1	---
2	II/20	9-3-75	389	1	---

Dog No.	Area/Plot	Date	Elapsed Time (sec)	No. of Egg Masses	Rate of Capture (E.M./min.)
2	II/20	9-3-75	73	1	---
2	II/20	9-3-75	7	1	---
2	II/20	9-3-75	93	1	.52
2	III/21	8-21-75	--	0	---
2	III/22	8-21-75	187	1	---
2	III/22	8-21-75	176	1	.33
2	III/23	8-21-75	254	1	---
2	III/23	8-21-75	25	1	.43
2	III/24	8-21-75	137	1	---
2	III/24	8-21-75	57	1	---
2	III/24	8-21-75	67	1	.69
2	III/25	8-21-75	159	1	.38
2	III/26	8-23-75	193	1	---
2	III/26	8-23-75	155	1	.34
2	III/27	8-23-75	288	1	.21
2	III/28	9-1-75	--	0	---

Dog No.	Area/Plot	Date	Elapsed Time (sec)	No. of Egg Masses	Rate of Capture (E.M./min.)
2	III/29	9-2-75	76	1	.79
2	III/30	9-2-75	--	0	---
3	IV/5	8-21-75	90	2	---
3	IV/5	8-21-75	360	1	---
3	IV/5	8-21-75	165	1	---
3	IV/5	8-21-75	30	1	---
3	IV/5	8-21-75	15	1	.55
3	IV/6	8-21-75	45	4	---
3	IV/6	8-21-75	15	2	---
3	IV/6	8-21-75	7	2	---
3	IV/6	8-21-75	188	3	---
3	IV/6	8-21-75	365	1	---
3	IV/6	8-21-75	10	1	1.23
3	IV/7	8-21-75	220	1	---
3	IV/7	8-21-75	95	1	---
3	IV/7	8-21-75	45	3	---
3	IV/7	8-21-75	535	1	.40

Dog No.	Area/Plot	Date	Elapsed Time (sec)	No. of Egg Masses	Rate of Capture (E.M./min.)
3	IV/8	8-21-75	287	1	.21
3	IV/10	8-21-75	25	1	---
3	IV/10	8-21-75	300	1	.37
3	I/1	8-22-75	10	2	---
3	I/1	8-22-75	5	3	---
3	I/1	8-22-75	55	3	---
3	I/1	8-22-75	10	4	---
3	I/1	8-22-75	10	1	---
3	I/1	8-22-75	10	1	---
3	I/1	8-22-75	18	1	---
3	I/1	8-22-75	40	1	---
3	I/1	8-22-75	63	1	---
3	I/1	8-22-75	65	1	---
3	I/1	8-22-75	87	1	---
3	I/1	8-22-75	448	1	---
3	I/1	8-22-75	97	1	---
3	I/2	8-22-75	43	2	---

Dog No.	Area/Plot	Date	Elapsed Time (sec)	No. of Egg Masses	Rate of Capture (E.M./min.)
3	I/2	8-22-75	229	1	---
3	I/2	8-22-75	28	1	---
3	I/2	8-22-75	70	1	---
3	I/2	8-22-75	56	1	---
3	I/2	8-22-75	9	1	---
3	I/2	8-22-75	56	5	---
3	I/2	8-22-75	76	1	1.37
3	I/3	8-22-75	225	1	.27
3	I/5	8-22-75	251	1	---
3	I/5	8-22-75	167	1	.29
3	I/7	8-22-75	345	1	.17
3	I/9	8-22-75	180	1	.33
3	II/11	8-22-75	3	5	---
3	II/11	8-22-75	86	1	---
3	II/11	8-22-75	201	1	---
3	II/11	8-22-75	25	1	---
3	II/11	8-22-75	15	1	---

Dog No.	Area/Plot	Date	Elapsed Time (sec)	No. of Egg Masses	Rate of Capture (E.M./min.)
3	II/11	8-22-75	90	1	---
3	II/11	8-22-75	70	1	---
3	II/11	8-22-75	130	1	---
3	II/11	8-22-75	15	1	---
3	II/11	8-22-75	25	1	---
3	II/11	8-22-75	12	1	---
3	II/11	8-22-75	188	1	1.11
3	II/12	8-22-75	12	5	---
3	II/12	8-22-75	20	11	---
3	II/12	8-22-75	13	1	---
3	II/12	8-22-75	95	1	---
3	II/12	8-22-75	85	1	---
3	II/12	8-22-75	15	1	---
3	II/12	8-22-75	15	3	---
3	II/12	8-22-75	55	3	---
3	II/12	8-22-75	230	1	---
3	II/12	8-22-75	15	1	---

Dog No.	Area/Plot	Date	Elapsed Time (sec)	No. of Egg Masses	Rate of Capture (E.M./min.)
3	II/12	8-22-75	60	1	---
3	II/12	8-22-75	247	1	---
3	II/12	8-22-75	8	1	---
3	II/12	8-22-75	60	1	---
3	II/12	8-22-75	15	1	---
3	II/12	8-22-75	85	1	---
3	II/12	8-22-75	10	1	2.00
3	II/13	8-22-75	26	4	---
3	II/13	8-22-75	8	2	---
3	II/13	8-22-75	6	6	---
3	II/13	8-22-75	130	3	---
3	II/13	8-22-75	128	1	---
3	II/13	8-22-75	42	1	---
3	II/13	8-22-75	115	5	---
3	II/13	8-22-75	65	1	---
3	II/13	8-22-75	35	1	---
3	II/13	8-22-75	67	1	---

Dog No.	Area/Plot	Date	Elapsed Time (sec)	No. of Egg Masses	Rate of Capture (E.M./min.)
3	II/13	8-22-75	8	1	---
3	II/13	8-22-75	165	4	---
3	II/13	8-22-75	13	6	---
3	II/13	8-22-75	40	1	---
3	II/13	8-22-75	15	5	---
3	II/13	8-22-75	35	1	---
3	II/13	8-22-75	15	10	---
3	II/13	8-22-75	20	1	---
3	II/13	8-22-75	15	4	---
3	II/13	8-22-75	50	1	---
3	II/13	8-22-75	15	1	3.57
3	III/21	8-21-75	--	0	---
3	III/22	8-21-75	95	1	---
3	III/22	8-21-75	114	1	---
3	III/22	8-21-75	32	1	.25
3	III/23	8-21-75	--	0	---

Dog No.	Area/Plot	Date	Elapsed Time (sec)	No. of Egg Masses	Rate of Capture (E.M./min.)
3	III/24	8-21-75	92	1	.65
3	III/25	8-21-75	36	1	---
3	III/25	8-21-75	175	1	.57

APPENDIX C

PLOT DENSITIES AND NUMBER OF EGG MASSES CAPTURED IN AREA SEARCHES

APPENDIX C: PLOT DENSITIES AND NUMBER OF EGG MASSES CAPTURED IN AREA SEARCHES

Area/Plot	Total Egg Masses Present (>1m)	No. Egg Masses Captured	Percent Captured	Dog No.
I/1	22	21	95	3
I/2	13	13	100	3
I/3	1	1	100	3
I/4	4	3	75	2
I/5	2	2	100	3
I/6	1	0	0	2
I/7	2	1	50	3
I/8	6	4	67	2
I/9	1	1	100	3
II/10	3	2	67	2
II/11	20	16	80	3
II/12	37	35	95	3
II/13	61	60	98	3
II/14	10	8	80	2
II/15	11	9	82	2

Area/Plot	Total Egg Masses Present (>1m)	No. Egg Masses Captured	Percent Captured	Dog No.
II/16	37	36	97	2
II/17	19	16	84	2
II/18	20	18	90	2
II/19	19	14	74	2
II/20	6	6	100	2
III/21	0	0	---	2
III/22	6	2	33	2
III/22	4	3	75	3
III/23	3	2	67	2
III/23	1	0	0	2
III/24	4	3	75	2
III/24	1	1	100	3
III/25	3	1	33	2
III/25	2	2	100	3
III/26	2	2	100	2
III/27	1	1	100	2

Area/Plot	Total Egg Masses Present (>1m)	No. Egg Masses Captured	Percent Captured	Dog No.
III/28	0	0	---	2
III/29	1	1	100	2
III/30	0	0	---	2
IV/1	4	2	50	2
IV/2	2	2	100	2
IV/3	2	0	0	2
IV/4	1	1	100	2
IV/5	8	0	0	2
IV/5	8	5	63	3
IV/6	15	13	87	3
IV/7	8	6	75	3
IV/8	3	1	33	3
IV/9	2	2	100	2
IV/10	2	2	100	3

APPENDIX D

SUMMARY OF TIME PLOT SEARCHES (10 MIN.)

Appendix D: Summary of Time Plot Searches (10 min.).

Date	Nearest Two Area Plots	Elapsed Time (sec.)	Number of Egg Masses Discovered
8-25-75	I(9-10)	173	1
		117	1
		205	1
		30	4
		55	1
8-25-75	I(8-9)	242	1
		41	1
		10	1
		25	1
		132	1
8-25-75	I(7-8)	230	1
		259	1
		156	1
		175	1
8-26-75	I(3-4)	241	1
		357	1
8-26-75	I(3-4)	118	1
		119	1
		181	1
8-26-75	I(7-8)	---	0
8-26-75	I(4-5)	4	1
		26	1
		154	1
		227	1
8-26-75	I(4-5)	97	1
		241	1
		86	1
		116	1
9-1-75	III(27-28)	586	1
9-1-75	III(28-29)	425	2
		126	1

Date	Nearest Two Area Plots	Elapsed Time (sec.)	Number of Egg Masses Discovered
9-1-75	III(28-29)	451	1
9-2-75	III(22-23)	---	0
9-2-75	III(29-30)	---	0
9-2-75	III(29-30)	591	2
9-3-75	II(19-20)	132	5
		88	2
		80	1
		176	1
		122	1
9-3-75	II(19-20)	46	1
		130	1
		78	5
		164	1
		58	1
9-3-75	II(18-19)	52	1
		132	1
		60	1
		210	1
9-3-75	II(18-19)	111	1
		86	1
		267	1
9-3-75	II(17-18)	52	1
		60	1
		69	1
		121	1
		41	1
		34	1
		19	1
		28	1
		61	1
		57	1
9-3-75	II(17-18)	60	1
		32	2
		130	1
		69	1
		137	1
		142	1

Date	Nearest Two Area Plots	Elapsed Time (sec.)	Number of Egg Masses Discovered
9-3-75	II(16-17)	12	1
		46	1
		126	1
		164	1
		104	1
		69	1
		21	1
9-3-75	II(16-17)	73	1
		147	1
		95	1
		118	1
		78	1
		42	1
9-3-75	II(19-20)	132	5
		88	2
		80	1
		176	1
		122	1
9-3-75	II(19-20)	46	1
		130	1
		78	5
		164	1
		58	1
9-3-75	II(18-19)	52	1
		132	1
		60	1
		210	1
9-3-75	II(18-19)	111	1
		86	1
		267	1
9-3-75	II(17-18)	52	1
		60	1
		69	1
		121	1
		41	1
		34	1
		19	1

Date	Nearest Two Area Plots	Elapsed Time (sec.)	Number of Egg Masses Discovered
9-3-75	II(15-16)	63	1
		41	1
		83	1
		104	1
		50	1
		110	3
		61	1
9-3-75	II(15-16)	80	1
		40	1
		57	1
		7	1
		77	1
		119	1
9-3-75	III(24-25)	290	1
9-3-75	III(24-25)	525	1
9-3-75	III(23-24)	172	1
9-4-75	III(23-24)	83	1
		397	1
9-4-75	III(22-23)	10	2
		99	2
		371	1
		94	1
9-4-75	III(21-22)	268	1
		106	1
		154	1
9-4-75	III(21-22)	180	1
		228	1
9-5-75	III(27-28)	---	0
9-5-75	III(26-27)	---	0
9-5-75	III(26-27)	408	3
9-5-75	III(27-28)	166	1
		428	1

Date	Nearest Two Area Plots	Elapsed Time (sec.)	Number of Egg Masses Discovered
9-5-75	III(27-28)	---	0
9-5-75	III(25-26)	505	1
9-5-75	III(25-26)	---	0
9-5-75	I(1-2)	---	0
9-5-75	I(1-2)	22	1
		167	1
		49	1
		52	1
		144	2
9-5-75	I(2-3)	49	2
		71	1
		28	1
		144	1
		123	1
9-5-75	I(2-3)	10	1
		104	1
		14	1
		17	1
		29	1
		244	2
		144	1
		16	1
9-5-75	I(5-6)	64	1
		121	1
		88	1
9-5-75	I(5-6)	211	1
		29	1
		230	1
		52	1
9-5-75	I(9-10)	180	1
		254	1
		123	1
9-5-75	I(8-9)	495	1
9-5-75	I(1)	65	1
		128	1
		203	1
		49	3

Date	Nearest Two Area Plots	Elapsed Time (sec.)	Number of Egg Masses Discovered
9-5-75	I(10)	402	1
9-5-75	I(6-7)	254	1
		145	1
9-5-75	I(6-7)	57	1
		243	1
		193	1
9-6-75	IV(1)	510	1
9-6-75	IV(1-2)	106	1
		175	3
		270	1
		21	3
9-6-75	IV(1-2)	336	1
		84	2
		74	1
9-6-75	IV(2-3)	---	0
9-6-75	IV(3-4)	241	1
		231	1
		93	1
		34	1
9-6-75	IV(2-3)	36	1
		114	1
		30	1
		327	3
		36	1
9-6-75	IV(3-4)	217	1
		244	1
9-7-75	IV(4-5)	360	1
9-7-75	IV(4-5)	---	0
9-7-75	IV(5-6)	32	1
		139	1
9-7-75	IV(5-6)	245	1
9-7-75	IV(6-7)	427	1
		154	1

Date	Nearest Two Area Plots	Elapsed Time (sec.)	Number of Egg Masses Discovered
9-8-75	II(14-15)	50	2
		190	1
		125	1
		80	1
		109	1
		27	2
9-8-75	II(14-15)	65	1
		129	1
		106	1
		191	1
9-8-75	II(13-14)	38	1
		12	1
		130	1
		130	1
		98	1
		22	1
9-8-75	II(13-14)	15	1
		8	1
		85	1
		147	1
		19	1
		36	1
		118	1
		33	1
		97	8
9-8-75	II(12-13)	60	2
		125	1
		171	2
		41	2
9-8-75	II(12-13)	41	1
		89	1
		50	1
		101	1
		160	1
		81	1
9-8-75	II(11-12)	32	2
		9	1
		6	1
		12	3
		32	1
		27	5
		19	2
		14	1
		17	1
		22	1
		91	6

Date	Nearest Two Area Plots	Elapsed Time (sec.)	Number of Egg Masses Discovered
cont.		40	2
		53	1
		64	1
		53	4
		28	3
9-8-75	II(11-12)	71	2
		31	3
		35	1
		87	6
		16	1
		72	1
		12	2
		54	1
		55	1
9-8-75	II(10-11)	17	1
		55	3
		29	1
		157	6
		163	1
		70	1
		30	3
		30	1
		40	1
9-8-75	II(10-11)	115	1
		106	1
		138	3
		5	1
		77	1
		52	1
		57	1