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Population Sampling and Spatial Distribution of the Immature Life Stages of the Onion Maggot,

Hylemya Antiqua (Meigen) presented by

Raymond I. Carruthers

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POPULATION SAMPLING AND SPATIAL DISTRIBUTION

OF THE IMMATURE LIFE STAGES OF THE ONION MAGGOT, HYLEMYA ANTIQUA (MEIGEN)

Ву

Raymond I. Carruthers

A Thesis

Submitted to Michigan State University in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Department of Entomology

ABSTRACT

POPULATION SAMPLING AND SPATIAL DISTRIBUTION OF THE IMMATURE LIFE STAGES OF THE ONION MAGGOT, HYLEMYA ANTIQUA (MEIGEN)

by

Raymond I. Carruthers

The onion maggot, <u>Hylemya antiqua</u> (Meigen) is a continuous problem in onion production in northern United States and southern Canada. This study examines the spatial distribution of the immature life stages of this insect pest with the goal of developing accurate yet economically reasonable methods of density estimation.

The spatial distribution of the immature life stages were found to be highly aggregated at various levels, from the regional distribution of damage between fields down to the distributional pattern of maggots between onions. An ovipositional attraction for rotting and/or previously infested onions was found to exist, with a 20-fold increase in egg density on previously damaged onions.

Regional and field level sampling techniques were developed for estimation of both onion maggot plant damage and actual age specific densities. Sample costs were evaluated for various universes of concern, sample sizes, and levels of precision.

To my family

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INTRODUCTION

The onion maggot, <u>Hylemya antiqua</u> (Meigen), is one of Michigan's most economically devastating vegetable insect pests. Mr. William Riley, Chairman of the Michigan Onion Growers Research Committee has stated that the onion maggot is the number one problem in the production of Michigan onions. Unchecked, each onion maggot larva can destroy up to 28 onion seedlings in the loop stage (Workman 1958). With adult females producing as many as 250 eggs (McLeod 1965), damage potentials can be extremely high (7,000 onions per female). Perron et al. (1955) cites crop damage as ranging from 10 to 85 percent depending on the population density. Direct physical damage such as this, coupled with the fact that the onion maggot is a known vector of <u>Ervinia carotovora</u> (Jones) (Gorlenko et al. 1956), a soft rot bacterium, causes onion growers to exert much time, effort, and money towards its control.

Current control strategies consist of a granular soil insecticide at planting and directed foliar sprays for control of the adult flies. Michigan recommendations (Cress et al. 1976) call for a 3-day minimum between foliar applications. Several commercial acreages are now approaching that rate of application. However, the intense use of chemical control has caused severe problems in the onion-pestcrop ecosystem. During the late 1950's and early 1960's, field studies indicated a high level of onion maggot resistance to cyclodiene

insecticides throughout its North American and European distributions (Brown 1971, Gostick et al. 1971, Harris and Svec 1976, and Hennequin 1970).

Chapman (1960) states that conditions for the selection of onion maggot resistance are ideal under commercial field conditions, i.e., the onion maggot is confined to one primary host plant which is universally protected with a single type of insecticide over very large areas. Harris and Svec (1976) state that high levels of cyclodiene resistance developed quite rapidly after the initial indication that resistance was present. Resistance was first noted in Michigan during 1958 (Guyer and Wells 1959) and a major effort was made to shift away from the cyclodiene insecticides to the organophosphate group which immediately was used to control the maggot.

The organophosphates have been used intensively since the early 1960's with a gradual decrease in their effectiveness. Harris and Svec (1976) attribute this decline in effectiveness to low level resistance. In testing several onion maggot population strains over the past 12 years for tolerance levels to various insecticides, two Michigan strains (Gun Marsh and Grant) were found to have significant increases in their level of parathion tolerance (2.8x and 5.1x, respectively). The Grant strain was found to have the highest level of resistance. This coincides with field observations, as Michigan's most severe onion maggot damage has been in the Grant area. Resistance levels found throughout the tested strains are considered low level, but highly significant. Brown (1971) points out that organophosphate resistance develops slowly, usually requiring three developmental stages: 1) the development of a latent period involving many

generations of selection, 2) the development of a polyfactorial system leading to low level nonspecific resistance, and 3) the development of a monofactorial system leading to higher levels of specific resistance. Harris and Svec (1976) feel that the onion maggot is closely following the pattern described by Brown. Many growers are still increasing their insecticidal application rates and application frequencies with little increased control.

The future of the existing onion maggot control program is questionable. Other alternatives must be explored and viable means must be adopted to integrate alternate control procedures into commercial operations. Such alternatives can only be designed when adequate biological information concerning the system dynamics is known.

Basic to population dynamics research and certainly to applied pest management is the ability to estimate actual insect densities and their effects in terms of host plant damage. Methods for such estimates are presently lacking for the onion system; it is the goal of this report to develop methods by which both plant damage densities and actual insect densities per life stage can be estimated for future research and pest management goals.

LITERATURE REVIEW

The literature concerning <u>Hylemya antiqua</u> (Meig.) is quite voluminous with the majority being insecticide oriented and of little value in the accumulation of biological information. Scott (1969) assembled an extensive bibliography for <u>H</u>. <u>antiqua</u> covering the majority of the published material with the exception of taxonomic citations and actual spray calendars.

Several authors (Doane 1953, Tozloski 1954, Workman 1958, Ellington 1963, and Loosjes 1976) have reviewed and collated much of the important biological literature concerning <u>H</u>. <u>antiqua</u>. The material presented in the following review is a resume of previous investigations that lend pertinent information in the areas of taxonomy, geographic distribution, life history, developmental rates, fecundity and longevity, survival, parasitoids and predators, diseases, rearing and nutrition, and spatial distribution and sampling.

Taxonomy

The taxonomic history is given by numerous authors. Most recently descriptions have been given by Huckett (1924), Doane (1953), Tozloski (1954), and Workman (1958). Keys that are useful in species identification have been compiled by Brooks (1951), Doane (1953), and Huckett (1971).

Geographic Distribution

A distributional map with a list of the areas inhabited by \underline{H} . <u>antiqua</u> was published by the Review of Applied Entomology (Distribution Maps of Insect Pests, Series A, Map No. 75, issued June 1977). Ellington (1963) gives a brief update of the fly's distribution in Europe.

Life History

In Michigan there are typically three distinct generations per year which overlap somewhat due to the longevity of the adult flies. The adults emerge from overwintering pupae in late April or early May. The exact date and length of the emergence period is dependent on temperature and depth of the overwintering pupae in the soil. As the soil profile warms, the pupae break diapause with the pupae closest to the surface emerging first. Developmental zero for the diapaused pupae is close to 40° F (Eckenrode, Ven and Stone 1975).

Newly emerged adults are soft-bodied and require a day to dry and harden. At this time the fly emigrates to field borders and feeds on pollen from wild flowers and other weeds. The preovipositional period lasts about 10 days, varying slightly with micro-climatic fluctuations (Theunissen 1976).

When gravid females move back into the onion field, they lay their eggs on the surface of the soil around the base of the plant in the leaf axils. After ecolosion the newly hatched first instar larvae move into the base of the onion bulb and feed, quickly disrupting the plant's vascular system which then shows signs of acute water stress. Lesions then open on the bulb surface which allows an invasion of

microorganisms, primarily soft rot bacteria such as <u>Erwinia corotovora</u> (Jones). The microorganism development increases the rate of tissue degeneration within the onion and produces symptomatic damage. (Doane (1953) gives an indepth description of the onion maggot soft rot damage symptoms.) Onion damage is first characterized by flacid leaves, followed by leaf tip yellowing, and then complete foliage dehydration. With prolonged damage the bulb is completely consumed by the onion maggot soft rot attack, leaving only the desiccated leaf tissue and the outer bulb sheath. At this point the maggot moves into the soil and pupates or migrates to succeeding onions until development is completed (Workman 1958). Kendall (1932) reported that 96.6% of second generation flies reinfest previously infested onions.

In the early part of the growing season, one maggot may consume numerous seedlings, resulting in a high rate of plant damage and mortality. As the season progresses and bulb size increases, one onion will support many more maggots, resulting in a doming of the damage curve (Loosjes 1976). Many traditional sampling schemes fail to deal with this functional shift; therefore, population estimates (adults and larvae) are often erroneously equated with damage predictions which often results in unnecessary spray applications.

Pupating third instar larvae migrate from the onion plant to the soil where the puparium is formed. The non-diapausing pupal stage lasts about 13 days before the following generation adults emerge. The newly emerged adults of the second and third generations follow the same developmental pattern as the first. A small percentage of the second generation pupae and a high percentage of the third enter

diapause (LaFrance and Perron 1959). Diapause is induced by the exposure of the late developing third instars and early pupae to low temperatures and a shortened photoperiod (Theunissen 1976).

Developmental Rates

Numerous observations concerning developmental rates have been made under a variety of laboratory and field conditions. Ellington (1963) reviewed the literature concerning this area and tabulated the results. Finding the existing data inconsistent, Ellington conducted laboratory experiments to define the developmental rates for eggs, larvae and pupae at various constant temperatures. Ellington's findings as well as other developmental data are discussed further in Appendix A.

Fecundity and Longevity

The ovaries of <u>H</u>. <u>antiqua</u> are meroistic polytrophic which results in a cyclic ovipositional activity (Missonnier and Stengel 1966). Due to the gravid female's ability to oviposit over an extended period of time, laboratory fecundity and survival studies have proven unreliable in the field. The variability of experimental results suggests a great need for additional field experimentation in this area.

Survival in Relation to Abiotic Factors

Ellington (1963) discusses egg, larval and pupal survival under a variety of temperature and relative humidity regimes in the laboratory. A review of the literature reveals the lack of completed work associating abiotic field conditions (temperature, relative humidity, soil moisture, etc.) with onion maggot survival. Although qualitative

assessments linking these phenomena have been noted, no attempt has been made to quantify them. Workman (1958) qualitatively split soil moisture into three arbitrary classes (saturated, moist and dry) for greenhouse experiments. Data of this type is quite common, but is of little value for estimating actual field survival rates. Using the work of Ellington (1963) and others (Sleesman 1936, Doane 1953, Gray 1924, and Workman 1958) high moisture situations seem to increase the survival of egg and larval stages.

Parasitoids and Predators

Perron (1972) discusses several parasitoids and predators that were present in non-pesticided organic soil plots in the Ste. Clotilde region of Quebec (1951-1966). A staphylinid beetle, <u>Aleochara bilineata</u> (Gyllo), was most effective. <u>A. bilineata</u> as a larval parasitoid is capable of destroying 20% of the overwintering pupae (Perron 1972). It becomes a predator as an adult. A braconid wasp, <u>Asphaereta pallipes</u> (Say), was listed as the second most effective parasitoid, capable of destroying 12% of the overwintering pupae (Perron 1972). Several other parasitoids and predators were listed with a short evaluation of each.

Ritcey (personnal communication, University of Guelph) stated that less than 10 parasitized individuals were observed from the thousands of field-collected pupae in Ontario commercial production areas. It is believed that heavy pesticide usage (soil treatment at planting and weekly foliar applications) has effectively eliminated the natural enemy complex of the onion maggot from these areas.

Disease

Entomophthora muscae (Cohn) has been identified as a naturally occuring fungal pathogen of <u>H</u>. <u>antiqua</u> (Perron and Crete 1960, Krammer 1971, and Miller and McCallahan 1959). Perron and Crete (1960) cited <u>E. muscae</u> as the key factor suppressing outbreak levels of the onion maggot in Quebec. Infected flies could fly, mate and oviposit but at highly reduced rates. MacLeod et al. (1976) summarized Entomophthora species with muscae-like conidia; life histories, species identification, and a thorough bibliography are included.

Rearing and Nutrition

Rearing and nutritional information concerning <u>H</u>. <u>antiqua</u> has been researched and well documented. Mass rearing programs have been carried out by several workers (Rawlings 1953, Perron et al. 1951, Friend and Patton 1956, Workman 1958, Elmosa 1960, and Niemczyk 1964).

Niemczyk (1964) developed a rearing technique for implementation at the Agriculture Canada, Entomology Laboratory, London, Ontario where modifications have been made to increase production levels and efficiency. These implementations increased the facility's rearing capabilities to 2,000,000 flies per month (Harris personal communication 1976) and are used for rearing laboratory colonies at Michigan State University (Appendix D).

Friend et al. (1956 and 1957) defined complete nutritional information, including amino acid and vitamin requirements. Additional information concerning the accelerated development of <u>H</u>. <u>antiqua</u>, in the presence of microorganisms, has also been documented by Friend et al. (1959).

Spatial Distribution and Sampling

Even though little has been published quantifying <u>H</u>. <u>antiqua</u>'s spatial distribution in North America, numerous qualitative descriptions are found in the literature (Perron et al. 1955, Workman 1958, and Rawlins et al. 1960). These papers describe the maggot population as being distributed within and between fields in a clumped or an aggregated manner. In agreement with these findings, Loosjes (1976) examined various sets of sampling data from the Netherlands and cites the distribution as highly aggregate within fields.

Aggregation, or the tendency to be found in groups, causes significant increases in sample variation when compared with a randomly dispersed population (Taylor 1961, Southwood 1966, Pielou 1977, and Elliott 1977). This increase necessitates a larger sample size (n) to be collected for estimation of the population density given a fixed level of precision.

As sample costs can be expensive, several alternate methods of sampling (simple, multistage, stratified, etc.) have been used to reduce the sample variance, and thus the sample size (n) (Cochran 1963, and Jessen 1978).

Southwood (1966) and Elliott (1977) give excellent reviews of statistical sampling theory as it applies to sampling insect populations. Southwood also includes descriptions of several sampling methods and their uses. Several other authors have given excellent reviews of sampling theory and sampling methods associated with a wide variety of insect populations. Some of the most helpful publications are: Bliss (1967), Lewis (1973), Morris (1955 and 1960), Ruesink and Haynes (1973), and Taylor (1961).

METHODS

Plant Damage Sampling

Characteristic plant damage symptoms associated with onion maggot attack are easily noted in the field and are very useful for monitoring plant damage spatial patterns and plant damage densities. Plant damage sampling was conducted at both the field and regional level to gain insight into the mode, distribution and intensity of onion maggot attack.

Regional Plant Damage Sampling:

To examine the spatial patterns of onion maggot damage and the feasibility of developing a regional sampling program for plant damage assessment, an intensive sampling scheme was set up to explore the allocation of regional variation in plant damage for various densities and sample unit sizes. Pest management field assistants, trained to recognize onion maggot damage symptoms, collected the sample data. Visually unbiased sample locations were selected by throwing an object into the onion field and using its landing point as the start of a sample unit. The field assistants paced along a 100 foot sample strip and recorded the number of damaged onion plants and their respective locations by one foot increments. This sampling procedure was repeated 10 times per sampled onion field.

Four major onion producing regions (Figure 1) were monitored four times throughout the growing season. The first sampling period



FIGURE 1. Michigan map with regional sampling areas indicated.

coincided with initial spring damage and was designed to gather data on the patterns of initial attack and the viability of the techniques associated with the sampling program itself. For this sampling period, field assistants were instructed to sample only one or two fields with known onion maggot damage and report any difficulties that arose during the procedure. The remaining three sample periods were planned to coincide with estimates of peak larval damage of the first, second, and third generations. Degree-day estimates were made using both previous trapping data and individual degree-day requirements of each life stage. These degree-day estimates (see Appendix A) were tracked in an on-line mode by PETE (Predictive Extension Timing Estimator) (Welch et al. 1972) throughout the four onion producing regions sampled. Automatically generated messages were sent to the respective field assistants via PMEX (Pest Management EXecutive system) (Croft et al. 1976) as their regional sampling dates approached. Sampling dates were estimated one and two weeks in advance to allow the field assistants to allocate specific time intervals for an intensive sampling period.

Table 1 summarizes the phenology and amount of monitoring executed during each of the four sampling periods. Three of the four planned sampling periods were executed as designated. The final sampling period was cancelled because visual discrimination between infested and healthy plants became difficult as normal foliage die-back masked the onion maggot damage symptoms. Appendix C lists the sampling data for each region and sampling period. These data are listed by the foot as it was collected by the field assistants.

SAMPLING PERIOD	REGION	MONITORING DATES	NUMBER FIELDS SAMPLED
Preliminary Sample	Bravo Grant Imlay City Jackson - Eaton - Ingham	5/13 5/17 5/20	с ц с ц
First Generation Peak	Bravo Grant Imlay City Jackson - Eaton - Ingham	5/26 - 6/2 6/2 - 6/7 5/31 - 6/17 6/6 - 6/10	6 6 13
Second Generation Peak	Bravo Grant Imlay City Jackson - Eaton - Ingham	7/7 7/14 - 7/20 7/13 - 7/22 7/6 - 7/20	4 10 15
Third Generation Peak	Cancelled -	All Areas	

Sampling phenology for regional plant damage assessment. TABLE 1.

Thirty six different onion fields were monitored during the 1977 growing season and of those 36, only 18 information data sheets were completed and returned by the growers. Supplementary information concerning planting rate, planting configuration, seeding date, surrounding crops, insecticides used at planting, acreage and geographical location was collected for each field.

Field Level Plant Damage Sampling:

Field level plant damage was monitored annually in a muck vegetable producing area near Grant, Michigan. The annual sampling periods were planned to coincide with peak second generation larval damage since the cumulative onion damage curve normally approaches its maximum yearly value (Loosjes 1976) and onion maggot plant damage symptoms are most easily identified during the mid summer months when water stress is normally high.

Adult flight activity was monitored throughout the growing season and was used as a timing indicator of second generation emergence. Degree-day estimates of second generation peak damage were calculated using the peak second generation adult trap catch as a baseline to which the mean physiological time (600 degree-days, base 39) necessary for third instar development was added (see Appendix A). Degree-day accumulations were monitored on-line via PMEX (Croft et al. 1976) and sampling dates were set as the actual accumulations approached the estimated plant damage peak. The estimated adult activity peaks and the actual sampling times (predicted peak damage) for the Grant area are listed in Table 2 by date and degree days.

Estimated a	Adult Activity Peak	Actual	Sampling Time
DATE	DEGREE-DAYS	DATE	DEGREE-DAYS
7/14 1976	1950	8/3 1976	2550
7/15 1977	2360	8/4 1977	2970

TABLE 2. Predicted adult and larval density peaks for Grant, Michigan in 1976 and 1977.

The number of damaged and healthy onion plants was recorded for 50 one-meter samples per field; data on field locations, on surrounding crops, and on several other specific observations (i.e., plant disease occurrence, special soil conditions, heavy wind damage, etc.) was also recorded.

Twenty three onion fields in 1976 and 17 onion fields in 1977 were sampled. The resulting data is listed in Appendix B along with an analysis of the effect of soil calcification on onion maggot damage. Field locations varied between years (Figure 2) as rotation with either carrots, celery, or a cover crop was common. In both seasons, the sampling was completed in approximately 24 man hours, including the time spent within fields and the time spent moving between fields.

Within Field Sampling for Age Specific Onion Maggot Density

Onion maggots are typically characterized as occurring in an aggregated pattern within and between fields (Loosjes 1976). Aggregation causes significant increases in sample variation; thus, a larger sample size (n) must be collected for precise estimation of population density. For estimation of age specific densities, simple random sampling is impractical, because the cost of data collection is extremely high. Individual onions must be pulled and dissected; the surrounding soil must be sifted; and the immature stages of the attacking insects must be identified, counted and recorded. Therefore, the processing cost per onion is quite expensive, and an efficient sampling strategy must avoid large sample sizes.



The necessity to make age specific density estimates requires that an alternate sampling strategy be researched, with the goal of minimizing the necessary resources while providing a reasonable level of precision. Many sampling techniques including sample frame selection, stratified random sampling, and cluster sampling produce significant gains in overall precision and sample costs, if the proper relationships exist in the population under investigation (Cochran 1963, and Jessen 1978).

Sawyer and Haynes (1978) have utilized stratified random sampling to optimize efficiency in estimating the density of the cereal leaf beetle, <u>Oulema melanopus</u> (L.), in five distinct habitats, as the per unit area means and the relative habitat sizes were of significant difference.

Two classes or strata of onions (visually healthy and visually damaged) have already been mentioned; obvious differences are readily notable in the population parameters (μ and S²) that lead to the use of stratified random sampling. To better examine the habitat structure each group was subdivided. Under the visually healthy class is, 1) onions which are one or more feet removed from damaged plants, and 2) onions which are within a damage clump or less than one foot removed. Under the visually damaged class is, 3) onions exhibiting typical signs of onion maggot damage (flacid and slightly yellowed leaves), 4) onions showing signs of severe degradation from onion maggot attack (leaves highly dehydrated, yellowing over 75% and typically decomposing with a soft rot bacteria), and 5) onions missing (assessed only if within an area of apparent onion maggot damage).

Periodic sampling throughout the 1977 growing season was essentially three-part. First, a plant damage survey, as described in the preceeding within field sampling section, was conducted to estimate the frequency of damage within the test field. Second, one hundred visually healthy onions were selected from the field and visually examined for signs of any onion maggot life stage. These onions were not removed from the soil, but the onion-soil interface and the leaf axiles were closely examined for egg deposition and sites of possible larval feeding. The third, and largest portion of the sample, consisted of grading and monitoring onions within damage clumps. Individual onions within a damaged area were numbered and then visually graded as to classes (described above). The spatial location of each onion plant in a clump was recorded using a two dimensional (x,y)coordinate system; (o,o) was set at the northwestern most onion in the clump. The onions were then removed from the soil and on site dissections were made whenever possible; when not possible, the onions were transported, individually packaged, to the laboratory where they were held at 40°F until they could be processed for determination of the number and life stage of the specimens within. The soil beneath each plant was sifted on site with both the number of viable and previously emerged pupae recorded. The pupae were returned to the laboratory where they were allowed to emerge for purposes of identification and parasitoid detection. This process was typically repeated in several independent clumps of damage to provide an estimate of within and between clump variation.

Ovipositional Behavior

A study investigating the site selection of the onion maggot was initiated in 1976 in a heavily infested commercial onion field in Grant, Michigan. This experiment was designed to test the ovipositional preferences of the gravid onion maggot female. Observational biology and the literature (Kendall 1932) suggest that the gravid female favored a combination of rotting and/or previously infested onions for oviposition.

A three-way factorial design was utilized within the field (bulb type, bulb condition, and bulb location). The treatments consisted of: 1) Immature bulbs (small green bulbs, 3/4" in diameter), Mature bulbs (large green bulbs, 2 3/4" to 3" in diameter), and Mature and Dry bulbs (large dry bulbs, 2 3/4" to 3" in diameter); 2) Rotting (R), Rotting and Infested bulbs (R + I), and Normal bulbs (N) (each R + I onion was preinfested with 3rd instar maggots); and 3) and area outside of, but along the periphery of field (A), and area within the three bordering rows of field (B), and an area in the geographic middle of field (C).

The onions were placed in flats containing 3 inches of muck and were assigned random locations in their respective areas (A, B, or C). The flats were left in these locations for eight days. It was believed that this was enough time to obtain sufficient oviposition without severe alteration of the treatments.
At the end of the eight day period the flats were removed from the field. Dissections were performed to determine the presence of new larvae and eggs. The implanted 3rd instar larvae were in pupal or prepupal form and were easily distinguished from the newly attacking larvae.

RESULTS AND DISCUSSION

Spatial Patterns

The study of spatial patterns of insect pests is an interesting aid in the handling of data for statistical analysis, and in gaining an understanding of the underlying biology which creates such patterns. An understanding of these factors enhances our ability as managers to manipulate pest populations within a cropping system.

Onion maggot damage is frequently cited as being dispersed in a clumped or aggregated manner (Kendall 1932, Perron et al. 1955, Workman 1958, Rawlins et al. 1960, and Loosjes 1976). These observations were mainly qualitative assessments of plant damage, with the exception of Loosjes who used quantitative techniques to evaluate within field onion maggot damage patterns in the Netherlands.

To further quantify the spatial configuration of the onion maggot, its associated plant damage and the underlying biology, the following analysis utilizes descriptive, analytical, and experimental techniques.

Statistical Distributions:

The plant damage data and the actual onion maggot counts per onion have been examined for conformity, or fit, to theoretical probability density functions. The observed populations are known to be contagious ($s^2 > \bar{x}$), thus the negative binomial distribution (NBD)

was used as the primary model. At extremely low density levels, the expected model was altered to the poisson, as it has long been considered the "rare events" distribution by statisticians (Steel and Torrie 1960).

The fit of the NBD to the observed data sets was evaluated using the procedures outlined by Elliott (1977). Initial estimates of the NBD parameter K were calculated using the moment estimation method (Equation 1)

$$\hat{K} = \frac{\bar{x}^2}{s^2 - x}$$
(1)

and refined by the iterative maximum likelihood estimator (Equation 2)

$$N \cdot \ln \left(1 + \frac{\overline{x}}{\widehat{K}}\right) = \sum_{x=0}^{m} \left(\frac{A(x)}{\widehat{K} + x}\right)$$
(2)

Where: N = total number of samples
x = frequency class
A(x) = total number of counts exceeding x
m = total number of frequency classes

Given K, the expected NBD frequencies were calculated from equations 3 and 4 then tested against the observed frequencies with a chisquare goodness of fit test.

$$P(o) = (1 + \frac{\bar{x}}{K})^{-K}$$
 (3)

$$P(x) = (\frac{K + (x - 1)}{x}) (\frac{\bar{x}}{\bar{x} + K}) P(x - 1)$$
 (4)

In the case of the poisson distribution, the expected frequencies were calculated from Equation 5, also being tested against the observed data

$$P(x) = e^{-m} \frac{m^{x}}{x!}$$
 (5)

with a chi-square goodness of fit test.

When arbitrary physical units are used to sample in a continuous universe, as is the case with the plant damage samples, the NBD parameter K has no absolute biological significance. The value of K, as with many other measures of aggregation, differs with changing sample unit sizes. Although no absolute biological meaning can be related to these values, they are measures of aggregation within a single sampling scheme and should only be used to evaluate the deviation from the random within fixed sampling techniques.

Actual onion maggot counts are also examined on a per onion basis within clumps of visual damage. The sample unit (the onion) is considered a discrete unit of habitat, thus a standard from which aggregation can be measured.

Field level aggregation (clumping between fields within a region) was evaluated using plant damage data sets (III A - 1 + 2) and frequency distributions generated from subsamples pooled on a field basis for each region and sampling period. The results are presented as Table 3. The field level analysis clearly shows the high aggregation noted between fields. Seven of the eight regional data sets fit the NBD with the eighth set fitting a poisson distribution due to low damage levels (only 1 damaged onion in 15 fields was observed). The two year analysis from Grant revealed that both data sets easily fit the NBD. Evaluation of the variance in the parameter K over the range of sample means indicates that no common clustering is found at the field level. (Further explanation of a common K will be discussed as it relates to within field analysis.) The lack of a common K or aggregation coefficient is easily understood, particularly at the field

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Fit of the negative binomial	100 foot and 1 meter samples.
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TABLI	

		NUMBER	SAMPLE	1				c	
DATE	AREA	OF FIELDS	UNIT SIZE	×	w ۲	×	DF	ײ	DIST
6-77	Grant	Q	1001	14.83	659.77	0.535	m	4.400	NBD
6-77	Bravo	9	1001	33.00	1373.60	0.220	m	2.115	NBD
6-77	Lapeer	6	1001	27.13	2492.70	0.160	9	1.400	NBD
6-77	Tri-county	13	100'	4.46	84.60	0.270	6	8.057	NBD
77-7	Grant	7	100	3.571	47.286	060.0	ę	2.310	NBD
77-7	Bravo	٢	100'	32.50	2583.30	0.125	Ч	2.530	NBD
77-7	Lapeer	10	100'	31.20	5801.73	0.125	4	1.831	NBD
77-T	Tri-county	15	100'	0.067	0.067	8			NOSSIO4
8-76	Grant	23	l meter	17.09	220.94	1.440	10	7.970	NBD
8-77	Grant	17	l meter	20.59	1001.63	0.451	6	3.582	NBD

level. Many variable factors, natural and man manipulated, cause great environmental variability between fields (i.e., moisture levels, insecticide types, insecticide rates, planting configurations, etc.), resulting in extreme variability in the observed spatial pattern (thus the variability in the parameter K).

Within field aggregation was examined using the same data sets, only each field was analyzed separately based on the subsamples taken within fields (regional data 10-100 foot samples per field, Grant data 50-1 meter samples per field). Table 4 presents the results of this analysis for both data sets. Sixty nine fields from the regional data set were independently analyzed; 39 recorded no detectable damage, four recorded only one observation (determining poisson), and 26 recorded multiple data observations each of which was successfully fit to the NBD. Of the 40 fields examined in Grant, six had no detectable damage, eight had observations of 0 and 1, and 26 had multiple frequency classes, all of which were fit with the NBD. Examinations within each of these data sets for a common K or common aggregation pattern is again of interest. Figures 3 and 4 show the inverse of the parameter K plotted against the mean for the regional data set and the Grant data set, respectively. Elliott (1977) states, the calculation of a common K is not applicable if there is a relationship between 1/K and the sample mean or if widespread scattering of the data is prevalent. In both cases no significant linear trend can be found, but the wide scatter between the points makes the use of a common K inappropriate.

Fit of the negative binomial distribution to the observed within field sampling distributions for 100 foot and 1 meter samples. TABLE 4.

DATE	AREA	NUMBER PER FIELD	SAMPLES UNIT SIZE	١×	s 2	Ж	DF	x²	DIST
6-77	Lapeer	10	100'	0	0	I	I	ı	4
				0	0	I	I	ı	ı
				0	0	I	ı	I	I
				0	0	I	I	ł	I
				4.7	69.122	0.3316	4	4.31	NBD
				14.3	251.122	0.805	ъ	7.33	NBD
				2.6	10.044	0.6964	e	2.61	NBD
				0.1	0.100	8	ı	I	POISSON
				1.3	7.122	0.1713	n	0.007	NBD
6-77	Bravo	10	1001	0.8	1.067	3.175	m	2.130	NBD
				0	0	I	I	I	I
				0	0	I	ı	ı	I

(continued)	
4.	
TABLE	

DATE	AREA	SAMPLES PER FIELD	SAMPLE UNIT SIZE	١X	s 2	м	DF	x²	DIST
6-77	Bravo	10	100'	6.5	105.389	0.2117	ß	6.71	NBD
				3.7	95.567	0.0555	4	11.7	NBD
				9.778	55.940	1.5110	7	7.37	NBD
6-77	Grant	10	1001	0	0	I	I	I	I
				0.6	1.600	0.3570	5	3.71	NBD
				6.7	66.900	0.3822	4	6.42	NBD
				0.7	2.456	0.2761	2	1.10	NBD
				0.3	0.456	0.4692	T	1.17	NBD
				0.6	1.820	0.1439	Ч	2.11	NBD
	Tri- county			0.2	0.400	0.0978	Ч	1.09	NBD
				0.4	0.711	0.2560	ę	3.91	NBD
				0.2	0.400	0.0978	Ч	3.11	NBD

(continued)
4.
TABLE

DATE	AREA	SAMPLES PER FIELD	SAMPLE UNIT SIZE	١×	s ²	К	DF	x²	DIST
6-77	Tri-county	10	100'	1.2	11.0	0.097	4	5.81	NBD
				0	ο	ı	ı	I	I
				0	0	I	ı	I	ł
				0	0	ı	1	I	I
				0	0	ı	I	ı	I
				0	0	ı	ı	I	I
				0.4	0.7111	0.255	e	2.93	NBD
				0	0	ı	ı	1	I
				0	0	ı	ı	I	ł
7-77	Lapeer	10	1001	0	0	I	I	I	I
				0	0	I	I	ı	I
				0	0	I	ı	I	I

DATE	AREA	SAMPLES PER FIELD	SAMPLE UNIT SIZE	١×	s2	К	DF	x²	DIST
7-77	Lapeer	10	100'	0	0	1	I	I	I
	1			0	0	ı	I	I	I
				24.3	157.3400	3.2916	7	10.33	NBD
				2.3	9.1220	0.4430	S	7.73	NBD
				1.5	5.1667	0.3375	m	3.73	NBD
				0.2	0.1800	8	i	I	NOSSIO
				2.6	12.4900	0.5440	9	7.92	NBD
	Bravo			10.7	211.5670	0.2805	4	3.11	NBD
				0	0	I	ı	I	ı
				0	0	I	ı	I	I
				2.3	15.1200	0.0950	m	3.325	NBD

DATE	AREA	SAMPLES PER FIELD	SAMPLE UNIT SIZE	١×	s 2	К	DF	x²	DIST
<i><i>LL</i></i>		C	1001	α	057 11	953C U	V	6 22	NBD
	פדמוור	01		0.1	001.11	0007.0	ŗ		1 an
				0.7	3.567	0.114	I	2.11	NBD
				0	0	I	I	I	I
				0	0	I	I	I	I
				0	0	I	1	I	I
				0	0	I	ı	I	I
				0	0	I	I	I	ł
	Tri-county			0.1	0.100	8	ł	I	I
				0	0	1	I	ı	ł
				0	0	I	I	I	ı
				0	0	I	I	ı	I
				0	0	1	I	I	I
				0	0	ł	ı	I	I
				0	0	ı	I	I	ı

DATE	AREA	SAMPLES PER FIELD	SAMPLE UNIT SIZE	١×	s2	Х	DF	x ²	DIST
7-77	Tri-county	10	100'	o	0	I	I	I	I
				0	0	I	ı	ł	ı
				0	0	ı	I	I	ı
				0	0	ı	ı	I	ı
				0	0	ı	ı	ı	I
				0	0	I	I	ı	I
				0	0	ı	ı	ı	ı
				0	0	ı	I	ı	ı
8-76	Grant	10	1001	0.2	0.500	0.054	7	4.64	NBD
				2.54	5.190	1.890	9	10.29	NBD
				0.72	2.287	0.233	9	3.75	NBD
				0.34	0.640	0.200	7	4.40	NBD

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DATE	AREA	SAMPLES PER FIELD	SAMPLE UNIT SIZE	١×	s 2	К	DF	x²	DIST
8-76	Grant	50	l meter	0.56	1.0270	0.73	ĸ	3.159	NBD
				0.56	0.9453	0.425	7	5.198	NBD
				0.94	3.2400	0.245	9	7.850	NBD
				0.20	0.4170	0.150	I	2.819	NBD
				0.14	0.2045	0.195	н	1.407	NBD
				0.92	5.5450	0.401	7	7.580	NBD
				0	0	I	I	I	I
				0	0	ı	I	I	I
				0	0	I	I	I	I
				0	0	ı	t	I	I
				0.04	0.0400	8	I	I	NOSSIO4
				0.06	0.0600	8	I	I	POISSON

(continued)	
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TABLE	

DATE	AREA	SAMPLES PER FIELD	SAMPLE UNIT SIZE	١×	s 2	м	DF	x²	DIST
8-76	Grant	50	l meter	0.02	0.0200	8	I	I	NOSSIOd
8-76	Grant	50	l meter	0.40	1.3100	0.205	2	8.840	NBD
				0.32	1.0380	0.112	2	5.110	NBD
				0.24	1.1200	0.045	9	11.630	NBD
				0.34	1.3310	0.745	ß	966.6	NBD
				0.70	1.4790	0.420	2	6.980	NBD
				С	0	I	I	I	I
				0.04	0.0400	8	I	ı	POISSON
				0.36	0.5210	0.540	7	1.05	NBD
				0.34	0.9637	0.104	4	4.25	NBD
				0.26	0.6450	0.100	e	2.25	NBD
				0.38	0.9400	0.168	4	5.57	NBD
				0.08	0.0750	8	I	I	I

(continued)	
ABLE 4.	

DIST	NBD	NBD	NBD	NBD	NBD	NOSSIO4	NOSSIO	NBD	NBD	I	NOSSIO
x ²	3.730	3.060	6.610	7.815	4.662	I	I	4.030	0.498	I	1
DF	4	1	4	m	7	I	I	m	7	I	
м	0.150	0.380	0.163	1.270	0.370	8	8	0.310	0.850	I	,
s 2	1.060	0.360	1.790	0.997	4.750	0.020	0.040	0.904	0.531	0	0.020
١×	0.26	0.26	0.58	0.68	1.32	0.02	0.04	0.44	0.40	0	0.02
SAMPLE UNIT SIZE	l meter										
SAMPLES PER FIELD	50										
AREA	Grant										
DATE	8-77										

•



Aggregation or clumping within fields was the dominant spatial pattern in this study, although no common K or clustering coefficient was found. These results agree with the within field spatial pattern analysis carried out by Loosjes (1976) on onion maggot damage in sandy soils in the Netherlands. Loosjes cites four reasons for within field clumping:

- 1. clustered egg deposition,
- oviposition preference for certain sizes or densities of onions,
- 3. strong ovipositional preference for previously damaged onions, and
- 4. possible density dependent survival,

but Loosjes states that no common aggregation coefficient can be specified as various combinations of these factors interact and produce different patterns. This study fully agrees with his conclusions with one major addition to the list of factors causing aggregation within fields. A fifth, and major, cause of damage aggregation in Michigan onions is the spatial distribution of the granular insecticide placed in the soil at the time of seeding (this aspect will be discussed in some detail later in this section).

The observed frequency distributions of actual onion maggot counts per onion within areas of defined onion maggot damage (strata 2-5 as discussed on page 19) were also fit to the negative binomial frequency distribution. Each independent clump of damage was analyzed separately (results listed in Table 5). All 26 separate clumps analyzed throughout the 1977 growing season clearly fit the NBD. Plotting 1/K against the sample mean (Figure 5) we find an indication of a common factor

1>							
<	°2	Z	K.	CHI-SQ df	CHI-SQ K	CHI-SQ K _c	TABLED CHI-SQ #
1.8510	8.869	47	0.2726	5	4.49	4.54	11.07
1.430	9.380	75	0.1882	ß	6.22	7.09	11.07
0.6881	5.328	109	0.1165	9	3.16	7.66	12.59
1.6220	15.700	53	0.1346	4	7.28	7.58	9.49
1.520	11.720	27	0.2133	m	1.41	1.31	7.82
0.833	3.286	36	0.3010	4	0.67	1.02	9.49
0.485	1.445	33	0.1870	4	4.20	7.34	9.49
0.730	3.203	37	0.3642	4	6.56	7.72	9.49
0.421	1.035	19	0.2302	m	3.19	3.32	7.82
0.839	5.744	62	0.1108	ъ	4.91	7.05	11.07
0.744	3.605	168	0.1771	7	9.11	9.78	14.07
0.976	10.103	126	0.1266	9	5.44	6.34	12.59
0.385	2.190	39	0.1073	2	0.98	0.85	5.99
0.4186	1.340	43	0.1220	m	2.65	3.39	7.82
0.4571	0.843	35	0.2895	2	5.73	5.65	5.99
0.333	1.333	12	0.0399	0	1	*	*
0.641	9.394	39	0.0138	1	0.65	*	3.84
0.160	0.223	25	0.3190	Ч	0.58	2.02	3.84
0.692	12.690	39	0.0235	1	0.06	*	3.84
0.421	3 . 368	19	0.0169	ı	0.39	*	3.84
2.148	16.704	74	0.3474	9	8.77	11.33	12.59
6.235	59.882	34	0.5240	S	1.65	5.58	11.07
5.083	69 564	36	0.4995	S	7.85	10.93	11.07
4.033	42.931	06	0.2404	6	10.70	11.25	16.92
7.073	62.869	41	0.2753	10	12.53	13.96	18.31
6.220	75.518	68	0.2380	8	11.03	06.6	15.51
	0.485 0.730 0.421 0.839 0.839 0.744 0.976 0.4571 0.4571 0.4571 0.451 0.451 0.641 0.692 0.692 0.692 0.692 0.692 0.692 0.692 0.633 6.235 6.233 6.233	0.485 1.445 0.730 3.203 0.421 1.035 0.421 1.035 0.839 5.744 0.744 3.605 0.744 3.605 0.744 3.605 0.744 3.605 0.744 3.605 0.744 3.605 0.385 2.190 0.385 2.190 0.4186 10.103 0.4571 0.843 0.4571 0.843 0.333 1.340 0.451 9.394 0.333 1.333 0.641 9.394 0.160 0.223 0.160 0.223 0.421 3.368 2.148 16.704 6.235 59.882 6.235 59.882 6.235 69.564 7.073 62.869 6.220 75.518	0.485 1.445 33 0.730 3.203 37 0.730 3.203 37 0.421 1.035 19 0.839 5.744 62 0.839 5.744 62 0.839 5.744 62 0.744 3.605 168 0.744 3.605 168 0.744 3.605 168 0.744 3.605 168 0.385 2.190 39 0.4186 1.340 43 0.4186 1.340 43 0.4571 0.843 35 0.4571 0.843 35 0.4571 0.843 35 0.4571 0.843 39 0.333 1.340 43 0.421 3.33 12 0.421 3.368 19 0.421 3.368 19 2.148 16.704 74 6.235 59.882 34 6.235 59.882 34 7.073 62.869<	0.485 1.445 33 0.1870 0.730 3.203 37 0.3642 0.730 3.203 37 0.3642 0.730 3.203 37 0.3642 0.730 3.203 37 0.3642 0.839 5.744 62 0.1108 0.976 10.103 126 0.1771 0.976 10.103 126 0.1771 0.976 10.103 126 0.1073 0.385 2.190 39 0.1073 0.385 2.190 39 0.1073 0.4571 0.843 35 0.2399 0.4571 0.843 35 0.2395 0.333 1.333 12 0.0339 0.4571 0.843 35 0.2395 0.4571 0.843 35 0.0399 0.4571 0.843 35 0.0399 0.160 0.2233 12 0.2395 0.160 0.2233 25 0.3190 0.6218 0.2690 39 0.0138	$\begin{array}{llllllllllllllllllllllllllllllllllll$	0.485 1.445 33 0.1870 4 4.20 0.730 3.203 37 0.3642 4 6.56 0.421 1.035 19 0.2302 3 3.19 0.839 5.744 62 0.1108 5 4.91 0.744 3.605 168 0.1771 7 9.11 0.744 3.605 168 0.1771 7 9.11 0.976 10.103 126 0.1266 6 5.44 0.385 2.190 39 0.1073 2 0.98 0.4186 1.340 43 0.1220 3 2.65 0.4333 1.340 43 0.1223 2 0.98 0.4333 1.333 12 0.0399 0 $ 0.3333$ 1.333 12333 0.1220 3 2.65 0.4186 1.340 43 0.1220 3 2.65 0.4186 1.340 43 0.1220 3 2.65 0.4186 1.340 43 0.1220 3 2.65 0.4186 1.333 1233 0.1220 3 2.65 0.4186 1.333 1.333 0.2239 0.0399 0 0.411 9.394 39 0.00399 0 0.658 0.6922 12.690 39 0.0235 1 0.065 0.6923 12.690 39 0.0235 1 0.066 0.6923 5.21683 69.56	$ \begin{array}{llllllllllllllllllllllllllllllllllll$

Fit of the negative binomial distribution to actual onion maggot counts within areas of damaged onions and application of a common K(K) of 0.2520. TABLE 5.



FIGURE 5. Negative binomial parameter k as a function of the sample mean for the total immature population per onion within areas of damage.

of aggregation. The value of K (1/K as plotted) seems totally independent of the sample mean and fairly stable about its mean. In opposition to this common factor of aggregation are four aberrant points at the low density range. These points are marked by an asterisk in Table 5. Closer examination revealed significant plant damage in these data sets, although the actual number of non-zero onion maggot observations was limited to one or two insects per data set. Comparing the indicated sample dates with Figure A-3 shows peak second generation emergence coinciding with these sampling dates. Removal of the majority of the population from the sampling universe (emergence as adults) is believed to be the cause of the deviation in the parameter K.

A common K (K_c) was calculated using all the data sets of Table 5, except those considered as outliers in the previous paragraph. A common K (K_c) of 0.252 was calculated as the arithmetic mean of the K_1 s. Table 5 lists the results of the chi-square goodness of fit test to the negative binomial distribution using the K_c value for the parameter K in each test. As indicated, the only significant deviations were those four outlying points previously described. The existance of a common K or common clustering coefficient at this within clump level, while not at higher levels seems probable for several reasons, 1) the higher the level examined, the higher the level of exogenous variability, 2) the environment, within any single clump or area of damage, is essentially homogeneous, and 3) the within clump level is the universe within which the immature stages of this insect actually operate. The within clump study was conducted in a single field; it is not yet known whether the common aggregation coefficient found in this study is independent of field differences. Clearly, the significance of these findings suggests that the onion maggot utilizes a common mode, within a localized population, to exploit its immediate environment.

Nearest Neighbor Analysis:

Quadrate sampling was used to analyze between and within field aggregation patterns. As mentioned earlier, the use of artificial sample quadrates biases the aggregation coefficient (K) of the NBD. No comparison between differing quadrate sizes is then possible. Distance sampling (Clark and Evans 1954, and Pielou 1977) completely avoids the use of arbitrary sampling units and their associated problems (Pielou 1977) by examining the distance between individuals within a population (nearest neighbor) or by examining the distance from a random point to the closest individual. Clark and Evans (1954) suggest the use of the ratio (Equation 6)

$$R = \frac{\bar{r}_{A}}{\bar{r}_{E}}$$
(6)

where: $\bar{r} = mean$ distance from random individuals to their nearest neighbor

> \bar{r}_E = mean distance from random individuals to their nearest neighbor if the population were distributed at random

as a means of the degree to which the observed data approaches or departs from random expectation. As Equation 6 clearly reveals, an R

value of 1.0 indicates a random distribution. The parameter is also bounded at both extremes, R = 0 for absolute aggregation (all individuals at one point) and R = 2.1491 for a uniform pattern.

Application of this technique at the between or within field level is somewhat awkward as the selection of totally random individuals would be difficult to manage. This technique was utilized on the data sets collected in the within field sampling study (the same set utilized for the fit of actual onion maggot count to the NBD). As described on page 20, the (x,y) coordinates of every onion within a clump were recorded. For this analysis, only the onions actually attacked by onion maggots were run through the analysis (algorithm, Clark and Evans 1954; computer program, Lampert and Untung 1978, and Untung 1978), which measured the within clump deviation of plant damage from random. Eighteen individual data sets were analyzed (results in Table 6). All data sets indicate a high degree of damaged plant aggregation.

Specific Spatial Pattern Studies:

Pupal Distribution in Muck Soil--In conjunction with the age specific onion maggot density sampling, two sample plots were excavated on August 3, 1977. A third sample plot was excavated on August 12, 1977. Three hundred and twenty nine pupae, surrounding 25 damaged plants, were extracted from the sample plots. Distances from the onion source, horizontal and vertical planes, were calculated with the resultant frequency distributions as given in Table 7 and Figures 6 and 7. A poisson distribution clearly fit the horizontal (Table 7 and

DATE	CLUMP	r	VAR	R	С*
6-23-77	1	0.1246	0.0075	0.1088	7.625
	2	0.1409	0.0106	0.1380	7.375
	3	0.1050	0.0053	0.0985	7.713
	4	0.1036	0.0028	0.0802	7.869
	5	0.1384	0.0048	0.0875	7.807
6-30-77	1	0.1604	0.6272	0.110	7.605
	2	0.1609	0.0039	0.0852	7.826
	3	0.2047	0.0698	0.1476	7.290
	5	0.2228	0.0212	0.1607	7.180
	6	0.1463	0.0093	0.1918	6.914
7-7-77	1	0.2249	0.0065	0.2505	6.412
	2	0.2332	0.0106	0.1142	7.578
	3	0.1251	0.0043	0.0662	7.989
	4	0.2228	0.0067	0.1260	7.477
7-29-77	1	0.1805	0.0106	0.2166	6.703
8-3-77	1	0.1407	0.0012	0.1379	7.375
	2	0.1269	0.0043	0.1319	7.426
8-12-77	1	0.1114	0.0023	0.1444	7.321

TABLE 6. Nearest neighbor analysis for within clump plant damage (distance in feet).

* C is compared against the standard variant of the normal distribution for a particular level of significance ($\alpha = 0.05 -$ SD = 1.96). C values greater than 1.96 are significantly different from random at the 5 percent level.

	DISTANCE FROM ONION	OBS	EXP	$\frac{(\text{OBS} - \text{EXP})^2}{2}$
	0-1	10	12 27	0 1215
T	0-1	12	13.27	0.1215
2	1-2	45	42.60	0.1352
3	2-3	61	68.40	0.8006
4	3-4	87	73.20	2.6000
5	4 -5	53	58 .7 0	0.5500
6	5-6	43	37.70	0.7451
7	6-7	11	20.10	4.1200
8	7-8	14	9.25	2.4400
9	8-9	1	3.70	1.9700
10	9-12	2	1.75	0.0360
		Σ329		13.5100

TABLE 7.	Observed horizontal pupal distribution around a source
	onion in muck soil as compared with a poisson distribution
	$(\bar{x} = 3.21)$. Tabled values are in terms of inches.

•

DF = 8 α = 0.05 Tabled x^2 = 15.507



FIGURE 6. Horizontal distribution of onion maggot pupae in muck soil from onion source.



FIGURE 7. Vertical distribution of onion maggot pupae in muck soil from onion source.

Figure 6) but no distribution was fit to the vertical distribution (Figure 7) due to the small number of frequency cells. Figure 6 shows that approximately 90% of the pupae were located within a six inch radius of the onion source. Figure 7 shows that approximately 100% of the pupae lie above the six inch depth.

Seasonal Distribution of Onion Maggots Per Bulb--Table 8 lists the mean number of immature onion maggots found per bulb along with associated variance. If the data is plotted over the onion bulb volume, a linear increase is observed (Figure 8), although considerable variance is noted about the regression line due to changing density levels as population maturation and adult emergence occur.

Ovipositional Preference--The experimental data (total eggs and larvae) was first analyzed using a three-way ANOVA (see Appendix F for complete data set). As no differences were found due to field locations, the data was pooled to increase the per cell replication from 6 to 18. A two-way analysis of variance was then used to test for differences. The analysis of variance was then used to test for differences. The analysis showed significance for both factors (bulb size and bulb condition) as well as an interaction (Table 9). A plot of the means (Figure 9) and the per cell statistics (Table 10) show the treatment results.

Bulb type showed an obvious effect due to bulb size: small bulbs were found with a reduced mean, while large green bulbs and large dry bulbs (high mean) showed no significant differences. All three treatments of bulb condition (R, R + I, N) were significantly different. Rotting and Infested (R + I) were the most attractive. Rotting (R)

DATE	MEAN	VARIANCE	MAXIMUM DENSITY/BULB
6-23-77	4.40	17.41	20
6-30-77	2.80	7.87	12
7-7-77	3.18	17.67	21
7-21-77	7.11	61.11	22
7-29-77	4.42	24.54	29
8-3-77	7.75	72.07	40
8-12-77	8.64	54.40	39
9-1-77	11.88	110.30	37

TABLE 8. Observed number of onion maggots per infested bulb in the Grant, Michigan test field.



FIGURE 8. Relationship between the mean volume number of onion maggots per bulb and the volume of the onion bulb.

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQ. ACRES	F	SIGNIFICANCE
Onion Type	3780.48	2	1890.24	31.68	0.001
Onion Condition	12519.51	2	6259.79	104.91	0.001
Interaction	3849.93	4	962.48	16.13	0.001
Error	9128.5	153	59.66		
TOTAL	29278.5	161			

.

TABLE 9.	Analysis of variance	table for total eggs and larve by
	onion type and onion	condition.



FIGURE 9. Plot of treatment means for ovipositional attraction experiment.

	Large D	ry Bulb	Large Gr	een Bulb	Small Gr	en Bulb
	x	C.L.	x	C.L.	x	C.L.
Rotten and	30.77	27.18	12.669	9.069	0.3889	0.0
Infested		34.38		16.264		3.98
Rotten	29.167	25.569	10.83	7.236	0.222	0.0
		32.764		14.430		3.819
Good	5.889	2.291	4.61	1.014	0.9444	0.0
		9.486		8.209		4.54

TABLE 10.	Cell	statistics	for	ovipositional	preference	ANOVA	experi-
	ment	(mean and 9	95%	confidence lim	its).		

Grand Mean = 10.6111

Total N = 162

 $\sigma_{\overline{X}}$ of Cell Means = 1.821

onions showed some attraction for oviposition, while healthy onions were essentially neutral (extremely low means). Although significant differences were found between R + I and R treatments, the results must be evaluated with respect to the experiment itself. It is believed that the differences found between the R and R + I treatments are partially due to onion desiccation in the R group during the exposure period. The addition of active larvae in the R + I treatment created higher moisture conditions throughout the test period. It is not known whether the difference noted was due to the higher moisture levels in the treatment, the continued maceration of bulb tissue by the implant larvae (thus an increase in onion volatiles), the presence of an actual ovipositional stimulant produced by the larvae, or other unknown factors.

Of significant importance is the verification of an ovipositional preference for rotting and/or infested onions for which this experiment, in conjunction with the findings of those from the age specific sampling study (discussed later) which revealed a 20-fold increase in eggs found on damaged (grade 3) onions as compared to adjacent healthy onions, gives quantitative proof.

Distribution of Initial Attack--Numerous field observations have noted a wide range of onion maggot damage patterns. Although aggregation is typically the rule, the range of aggregation varies highly between areas. As expected, the field-wide pattern of initial plant damage is also variable, but a common pattern, near random damage, was observed within limited areas of initial damage. In other words,

some fields showed high initial damage aggregation at the field level (1 or 2 rows heavily damaged, while the remainder of the field was damage free) but in areas of apparent damage (heavily damaged rows), the initial attack approached a random pattern.

To test these observations, early season plant damage samples collected by the pest management field assistants were analyzed. Six sets of early season damage samples, consisting of 10-100 foot samples per set, were collected in mid May (May 15 - May 20) with the number of damaged plants being recorded by the foot. The distance between damaged plants was calculated and a Runs test (Siegel 1956) was used to test for deviation from a random pattern within samples. The sampling distribution being tested under H_0 is considered approximately normal with:

Mean =
$$\mu_r \frac{2n_1 n_2}{n_1 + n_2} + 1$$
 (8)

Standard deviation =
$$\sigma_{r} \frac{\sqrt{2n n (2n n - n - n)}}{(n + n)^{2} (n + n - 1)}$$
 (8)

where: n = number of observations below the sample mean n = n number of observations above the sample mean 2 Therefore, the normal score Z (Equation 9) can be tested against the standard normal distribution for deviation from randomness.

$$Z = \frac{r - \mu_r}{\delta_r} \tag{9}$$

where: r = runs = number of sequential data observations above or below the mean

As multiple observations per sample were necessary for this test, only samples consisting of five or more damaged plants were evaluated. This reduced the number of fields available for analysis to three. As mid to late season damage is believed to be built from the same base pattern established from the initial attack, seven sets of data collected later in the same season were also evaluated. These sets all showed high aggregation (several damaged plants for each observation) but if they developed from an initially random base pattern the centroids of each clump should reflect the initial pattern of damage. In each of these sets, the distance between the clump centroids was measured and analyzed as above.

The results (Table 11) indicate that every data set tested (the initial plant damage and the centroids of damage clumps) showed no deviation from a random pattern. Therefore it is highly probable that the initial attack within a limited area of an onion field approaches a random pattern.

The actual field level damage patterns visualized do not reflect the total initial attack, only the successful attacks. The variability noted in the field level damage patterns is believed to be partially induced by natural environmental factors, but the natural selection of microhabitat may be overshadowed by pesticide induced mortality. Large areas of onions are often left vulnerable to onion maggot attack when, during seeding time, the application equipment, which places the granular soil insecticides in the furrow, malfunction. By random oviposition initially in the spring, such unprotected areas become flagged by damaged plants. This initial random damage quickly evolves into more highly aggregated patterns as the damaged onions begin

DATE	REGION	FIELD NUMBER	N	N	I X	л ^н	RUNS	12	SIGNIFICANCE
5-17-77	Lapeer	Ч	و	و	8.17	7.00	Q	-0.61	N.S.
5-13-77	Bravo	I	6	7	10.13	8.80	ω	-0.44	N.S.
5-17-77	Grant	1	6	9	15.00	8.20	6	0.45	N.S.
6-7-77	Lapeer	9	14	2	7.95	10.33	12	0.85	N.S.
6-15-77		7	46	18	7.31	26.88	97	-0.27	N.S.
7-22-77		9	75	36	7.90	49.65	42	1.67	N.S.
7-22-77		7	4	7	8.00	3.69	4	0.35	N.S.
7-15-77		10	4	4	5.75	5.00	4	-0.76	N.S.
6-2-77	Bravo	9	26	17	11.84	21.56	27	1.76	N.S.
6-6-77	Tri-county	13	٢	4	8.18	6.09	7	0.63	N.S.

Runs tests for distance between initial plant damage and clump centroids. TABLE 11.
attracting egg laying adults, thus allowing the population to locate areas of successful survival within a highly toxic environment.

If an insecticide become ineffective, due to improper placement, leaching, or insect resistance, initial damage is likely to occur randomly throughout the field, and later produce randomly dispersed clumps of damage throughout the field. Typically some intermediate condition exists between these two extreme cases, producing the variable intensity of aggregation noted in this study and in the literature.

Plant Damage Sampling

Regional Plant Damage Sampling:

The precision with which regional population densities can be determined is dependent on the amount and type of sample variations found throughout a region and the quantity of available resources for data acquisition. Regional sampling variation is essentially two part, consisting of within and between field variance components (Morris 1955, and Ruesink and Haynes 1972). The distribution, or relative amount of regional variation, allocated to each variance component, sets the structure within which the sampling program must be designed.

The sample variance for each region and sampling date was separated into its within and between field components using a one-way analysis of variance (Table 12) (Sokal and Rohlf 1969, and Jessen 1978). The mean square among (MS_A) estimates the between field variance component (S_b^2) of a region by Equation 10 and the mean square

Within (ME) and between (MS) mean square for four regions and two sampling periods calculated using a one-way analysis of variance (Sokel and Rohlf 1969). TABLE 12.

SAMPLING PERIOD	REGION	MS _E	đf	MSA	đf	×
First Generation Peak	Bravo	39.256	54	137.360	Ś	3.3000
	Grant	12.200	54	65.980	ъ	1.4830
	Imlay City	36.080	06	196.000	6	2.6000
	Jackson - Eaton - Ingham	5.373	117	8.460	12	0.4462
Second Generation Peak	Bravo	55.000	36	238.970	ę	3.1500
	Grant	2.186	63	4.729	9	0.3571
	Imlay City	19.800	06	589.760	6	3.1400
	Jackson - Eaton - Ingham	0.070	135	0.070	14	0.0670

error (MS_E) of the ANOVA estimates the within field variance component (S_{W}^{2}) directly (Jessen 1978).

$$S_{b}^{2} = \frac{MS_{A} - MS_{E}}{n}$$
 (10)

where: n = number of samples per treatment.

Both components of the regional sample variation $(S_b^2 \text{ and } S_w^2)$ are dependent on the sample mean, as is the total variation of many samples. A log variance-log mean function (Equation 11) has been used by several authors (Morris 1955, Wayman 1959, and Taylor 1961) to describe the variance to mean relationship of sampling data from various populations.

 $\log \sigma^2 = \log a + b \log \bar{x}$

or (11) $\sigma^2 = \mathbf{a}(\mathbf{\bar{x}})^{\mathbf{b}}$

Parameter "a" depends chiefly on the size of the sampling unit, while parameter "b" is an index of aggregation varying continuously from 0 for a uniform distribution to plus infinity for extremely contagious populations ("b" \rightarrow 1 when the population is randomly dispersed) (Taylor 1961).

The regression of log MS on log mean was used to estimate both parameters "a" and "b" for the within and between field variance components of the cumulative 100 foot samples (see Table 12). As seen in Figure 10 and the ANOVA Tables 13 and 14, excellent fits ($r^2 > 0.98$) were given for both mean square components. Finney (1971), Morris (1955), and Bliss (1967) have shown that the arithmetic means is underestimated when predicted from the geometric mean of a logrithmic





TABLE 13. Regression statistics for predicting within field mean square for the 100 foot sample unit.

SOURCE	DF	SS	ms
		11 1400	11 14000
Regression	1	11.1400	11.14000
Residual	6	0.2167	0.03612
Total	7	11.3600	

y intercept ("a") = 0.9152 ± 0.0699
slope ("b") = 1.399 ± 0.0865
r² = 0.9809

TABLE 14. Regression statistics for predicting between field mean square for the 100 foot sample unit.

SOURCE	DF	SS	ms
Regression	1	17.4800	17.4 80
Residual	6	0.2406	0.041
Total	7	17.7200	

y intercept ("a") = 1.543 ± 0.0708

slope ("b") = 1.719 ± 0.0823

 $r^2 = 0.9864$

regression plot. Bliss (1967) suggests Equation 12 to adjust for this biased regression estimate.

$$y = Antilog (a + b log x + 1.1513 S2)$$
 (12)

where: S^2 = error mean square from the analysis of variance table of the regression

The correction factor slightly raises the magnitude of the intercept (parameter "a") but has no effect on the slope (parameter "b") of the regression equation.

Equations 13 and 14 represent the Mean Square function predicted by the log MS log mean regression for within field and between field components respectively. Equations 15 and 16 represent the same relationships as Equations 13 and 14, but have been adjusted as suggested by Bliss.

$$MS_{w} = 8.28(\bar{x})^{1.40}$$
(13)
$$MS_{w}^{2} = 9.13(\bar{x})^{1.40}$$
(15)
$$MS_{b} = 34.9(\bar{x})^{1.72}$$
(14)
$$MS_{b}^{2} = 38.8(x)^{1.72}$$
(16)

Morris (1955) after segregating variance components used Equation 17 to solve for the total number of units (N_t) to be sampled, given several values of N_t and the number of subsamples per unit.

$$N_{t} = \frac{S_{bw}^{2} + S_{w}^{2}}{(S\bar{y})N_{w}}$$
(17)

where: $S\bar{y}$ = standard error of the predicted mean (logrithmic scale)

Morris goes on to show that the optimal sampling strategy, given the condition $S_b^2 > S_w^2$ is to take 1 subsample per unit ($N_w = 1$) as long as the time spent moving between units was not large compared to the time spent collecting a single sample within a unit. However, no consideration was given to sampling optimization in a finite universe, as in this case the sample units (trees in the forest) were essentially infinite when compared with the number drawn in the sample.

Ruesink and Haynes (1973), considering N_w (subsamples per grain field) to be 1, as the $S_b^2 > S_w^2$, used an equation (Equation 18) similar to that of Morris but included the necessary components to adjust for sampling in a finite universe for specific levels of precision.

$$N_{t} = \frac{S^{2}NF}{S^{2} + (a\bar{x})NF}$$
(18)

where: NF = total fields per region S^2 = total variance of the region a = precision level $(S_{\overline{x}}/\overline{x})$

Although this equation considers a finite universe, it will give erroneous results in a two-stage sampling program if the number of primary sampling units (fields per region) becomes limiting. As the number of grain fields per region was large, Ruesink and Haynes did not experience this problem. However, in onion production, the number of fields per region is much smaller and quickly becomes a limiting factor necessitating an increase in $N_{\rm ev}$ (subsamples per field).

Cochran (1963) discusses two-stage sampling and offers Equation 19 to describe the total variation by its within and between unit components. The approach considers a finite universe for both the sample unit and the number of subsamples per unit.

$$VAR(\bar{\mu}) = (\frac{NF - n}{NF})\frac{s}{n} + (\frac{M - m}{M})\frac{s}{mn} = (a\bar{\mu})^{2}$$
(19)
where: $\bar{\mu}$ = regional mean s_{b}^{2} = between field variance
 a = precision $(S\bar{x}/\bar{x})$ S_{w}^{2} = within field variance
NF = number fields/region M = possible subsamples/field
 n = number fields sampled/region m = number subsamples/field

A closed form method for evaluating the optimal number of samples within and between units is given (Cochran 1963) but it is dependent on the F distribution, which assumes normality. Normality cannot always be assumed, nor can a normalizing transformation always be made when sampling from low-medium density aggregated populations; therefore, an alternate approach is used. Solving Equation 19 for m (subsamples per field) we obtain Equation 20.

$$m = \frac{S_{w}^{2}}{n(a\overline{\mu})^{2} + \frac{W}{M} + S_{b}^{2}(\frac{n}{NF} - 1)}$$
(20)

The component S_w^2/M of the denominator is of little or no significance in this equation as most commercial onion fields are 10 acres or larger. Calculation of M (4,000 possible subsamples per 10 acre field) with division into the highest within field variance noted, produces an insignificant change in the estimate of m. To be conservative, the component S_w^2/M is considerd as 0, thus increasing the value of m for a safer estimate. The resulting expression can be written as:

$$m = \frac{S_{w}^{2}}{n(a\bar{\mu})^{2} + S_{b}^{2}(\frac{n}{NF} - 1)}$$
(21)

As the true population parameters, μ , S_b^2 , and S_w^2 , are not known and their sample estimates must be substituted, the square of one tailed standard score from the normal distribution (Z) must be included. (If the corresponding sample size is small, the t statistic must be substituted. (Karandinos 1976).) The statistics involved in this substitution necessitate the consideration of the probability statement associated with the confidence region about the mean (Equation 22).

$$\Pr(\bar{x}) = (Z_{\alpha/2}) \sqrt{\frac{s}{n}} < \mu < \bar{x} + (Z_{\alpha/2}) \sqrt{\frac{s}{n}} \simeq (1 - \alpha) \quad (22)$$

where: $\bar{x} = \text{sample mean}$
 $\alpha = \text{probability of type 1 error}$
 $Z_{\alpha/2}$ = the one tailed standard score of the normal distribution

Based on the Central Limit Theorem, the assumption of normality will hold true for the distribution of population means, even though the x_i 's may not be normally distributed (Steel and Torrie 1960). The value of Z depends on the confidence coefficient which is an arbitrary variable chosen by the researcher (typically 0.95). Setting the value at 0.95 a value of 1.96 is obtained for Z. Substituting Equation 15 for S_x^2 , the application of Equations 15 and 16 with Equation 11 for S_b^2 , and with the inclusion of Z^2 we obtain Equation 23.

$$m = \frac{(3.84) (9.13) (\bar{x})^{1.40}}{n (a\bar{x})^2 + (\frac{n}{NF} - 1) (\frac{(38.8(\bar{x})^{1.72} - 9.13(\bar{x})^{1.40})}{10.0})}$$
(23)

By examining Equation 19 it can be seen that the addition of sample units at the field level (n) decreases the within and the between field variation while an equal increase in the number of subsamples per field (m) only decreases the within field component of variation. Jessen (1978) states that when the cost of sampling primaries (fields) essentially equals that of the secondaries (subsamples per field) it is always optimal to increase the number of primary units to the maximum before increasing the number of subsamples. The only additional cost in sampling more fields is the cost of moving from one field to the next. The cost involved in moving between onion fields within a region is essentially zero as the fields are typically found in large geographic clusters due to the strict dependence on soil type.

Following the above logic given by Jessen (1978) and using reasonable estimates for \overline{x} , a, and NF (maximum NF seen < 40), it can always be seen that every field per region must be sampled before any reasonable level of precision can be reached.

By sampling every onion field in a region, the between field variance component can be eliminated from the denominator, leaving Equation 24, $(3.84)c^2$

$$m = \frac{(3.84)s^{2}}{NF(a\bar{x})^{2}}$$
(24)

or, in the case of the 100 foot sample unit:

$$m = \frac{(3.84)(9.13(\bar{x})^{1.40})}{NF(a\bar{x})^2}$$

from which the optimal number of samples (m) within each field can now be directly calculated for various combinations of \bar{x} , a, and NF.

An additional factor, the sample unit size in linear row feet (L), must be examined before the calculation of the optimal within field sample size (m). Taylor (1961) noted that the variance mean relationship changes as the sample unit size changes, thus directly affecting the optimal sampling strategy.

Sample data was recorded by one foot increments; sample unit lengths ranging from 1 to 100 linear row-feet were randomly extracted from each subsample. As before, an analysis of variance and a log variance log mean regression (the intercept "a" as adjusted by Bliss 1967) was performed to estimate the variance to mean relationship for all 100 values of L for the within and the between field cases. Although some decrease in between field variance was noted, the reduction was not significant, as even the smallest between field variance necessitated sampling every field per region.

The effect of L on the within field variance-mean relationship (Table 15) can be noted in Figure 11; the precision $(s_{\overline{X}}/\Re)$ of the pooled onion maggot damage data is plotted against the sample unit size (L). Given any set values for m and NF, the sampling precision steadily improves as L approaches 100 feet. Of greater importance, is the effect of the sample unit size on the number of samples per field and the related costs given a set level of precision.

To estimate the cost of sampling, the time involved in collecting data for various densities of damage was recorded. A linear function (Figure 12 and Table 16) was found to estimate the time in minutes necessary to sample 100 linear row feet for the density range examined (0-100 damaged plants per 100 foot strip). Movement between samples within a field is independent of the density and was found to take approximately 1 minute. Coupling these two time components (Equation 25) with Equation 24 and the ten variance-mean relationships of Table 15, the total cost of regional sampling can be compared for various values of L, \bar{X} , NF and a $(S_{\bar{X}}/\bar{X})$.

L	Adj "a"	"Ъ"	Coefficient of Determination (r ²)
10	14.24	1.51	0.91
20	14.16	1.54	0.95
30	11.09	1.48	0.94
4 0	9.74	1.48	0.96
50	9.13	1.45	0.96
60	8.58	1.48	0.97
70	9.11	1.49	0.97
80	9.26	1.43	0.98
90	9.35	1.41	0.98
100	9.13	1.40	0.98

TABLE 15. Within field variance to mean relationship as estimated by a log variance-log mean regression for various sample unit sizes.

General Form $S^2 = a(\bar{x})^b$





FIGURE 12. Sampling cost in minutes as a function of plant damage density.

SOURCE	DF	SS	ms
Regression	l	134.6	134.6
Residual	11	12.1	1.1
Total	12	146.7	

TABLE 16. Regression statistics for sampling time versus plant damage density.

y intercept ("a") = 1.741 ± 0.2908

slope ("b") = 0.09553 ± 0.008635

 $r^2 = 0.92$

As expected, given any set precision level, the larger sample unit required fewer samples to be taken per field (see Figures 13 and 14) except when m reaches the minimum value of one sample per field where L < 100 (possible only at high densities or low precision). The cost functions (Figures 15 and 16) indicate that the larger 100 foot sample units are the most efficient in terms of time spent sampling, again with the exception where $m \neq 1$ for L < 100. No sample unit sizes larger than 100 feet were examined, but as can be seen in Figures 15 and 16, the cost function has begun leveling off with minor increases in efficiency as L \neq 100. The exception is where low densities ($\bar{x} < 1$) and high precision ("a" < 0.1) are required.

The sample unit size of 100 row feet will be used to complete this analysis as it gives the maximum efficiency over the largest range of densities. Figures 17-20 give the optimal number of samples per field as calculated from Equation 23 for three levels of precision and four values of NF (total fields per region).

In this study only a portion of the fields within each of these regions were monitored, thus prohibiting precise estimates of their mean damage values. For future utilization of this sampling information it should be noted that regional means were found to lie in the range of 1.5 and 6.0 damaged plants per 100 foot sample. Using these expected mean values and Figures 17-20, the necessary number of subsamples per field (m) can easily be found for the three given precision levels.



FIGURE 13-14. Necessary subsamples per field for various densities, sample unit sizes, region sizes, and levels of precision (regional sampling).

FIGURE 15-16. Sample cost in minutes for various densities, sample unit sizes, region size, and levels of precision (regional sampling).



FIGURE 17-20. Necessary number of subsamples per field to achieve specified levels of precision at given densities and region size (regional sampling).

Field Level Plant Damage Sampling:

Determination of accurate within field plant damage densities, as with the preceeding regional densities, necessitates an understanding of the variance to mean relationship within the sample universe. As noted earlier, the variance of a sample mean depends on population density and dispersion, as well as the structure of the sample unit itself.

Cochran (1963) defines the variance of a sample mean derived from simple random sampling as:

	$VAR(\mu) = E(\bar{x} - \mu)^2 = \frac{S^2}{n} \frac{d}{dr}$	$\frac{(N - n)}{N} = (a\mu)^2$ (26)
where:	$\bar{\mathbf{x}}$ = field mean	<pre>n = number samples/field</pre>
	a = precision	μ = true population mean
	N = possible samples/field	S^2 = true population variance

The term (N - n)/N compensates for sampling within a finite universe, but as the sample size, n, is small in comparison to the possible number of samples, N, the resultant value approaches 1. To be conservative in estimating n, the value of (N - n)/N was set equal to 1.0, resulting in Equation 27.

$$VAR(\mu) = \frac{S^2}{n} = (a\mu)^2$$
 (27)

The true population parameters μ and S² are unknown, and the estimates \bar{X} and S² from sampling data must be used. Karandinos (1976), adjusting for the estimation of μ and S² and solving for n, transforms Equation 27 to Equation 28.

$$n = \frac{(Z_{\alpha/2})^{2} s^{2}}{(a\bar{x})^{2}} \quad OR: \quad n = \frac{(3.84) s^{2}}{(a\bar{x})^{2}} \quad (28)$$

where: $(Z_{\alpha/2})$ depends on the confidence coefficient which is an arbitrary variable chosen by the researcher (typically 0.95, which sets $Z_{\alpha/2} = 1.96$) Simple means and variances were calculated for numerous values of L (sample unit size) using the 71 sets of field data (Appendix C). As before, a log variance-log mean regression was fit for each test value of L which generated the regressions listed in Table 17. An identical regression analysis was performed on the 1 meter sample unit data collected from Grant, Michigan (Table 17). As the tabled values suggest, the resultant variance to mean relationships (3 foot and 1 meter) are not significantly different ($t_a = 0.3372$, $t_b = 0.6598$, Table t = 1.98; Cox 1976).

Equation 28 was linked with the variance to mean relationships of Table 17 (L - 10 \rightarrow 100, by 10) to estimate the sample size (n) for differing densities and precision levels. Figures 21 and 22 indicate, as expected, N decreasing as L increases. Of particular importance, apparent in both these figures, is the leveling effect noted in the slope of the function at the higher densities, which suggests optimum sample unit sizes less than 100 feet.

The cost function related to the within field sampling program is essentially equivalent to the regional sampling program, with two minor adjustments. The multiplicative factor associating the number of fields per region, NF, may be totally extracted, and the parameter representing movement between samples within fields is cut from 1 minute to 1/2 minute as the distance between samples is reduced approximately 50% due to the increase in the sample frequency per field.



FIGURE 21-22. Necessary samples per field for various densities, sample unit sizes, and levels of precision (field level sampling).

FIGURE 23-24. Sample cost in minutes for field level sampling.

	L	Adj. "a"	"b"	Coefficient of Determination (r ²)
	3	3.01	1.24	0.9733
	10	3.43	1.26	0.9703
	20	3.57	1.27	0.9727
	30	3.99	1.30	0.9761
	40	4.21	1.31	0.9802
	50	4.39	1.32	0.9815
	60	4.60	1.33	0.9859
	70	4.76	1.34	0.9857
	80	4.85	1.34	0.9866
	90	5.02	1.34	0.9867
	100	4.98	1.35	0.9877
*	1 meter	3.04	1.26	0.9562

TABLE 17. Field level variance to mean relationship as estimated by a log variance-log mean regression for various sample unit sizes (L).

*Independent data set from Grant, Michigan (1976-1977). General Form $S^2 = a(\bar{x})^b$

TABLE 18. Optimum sample unit size (L) as predicted by Equation 19 for various densities and levels of precision (densities based on 100 foot plots).

	10	20	30	40	50	60	70	80	90	100
2-0.1	1001	1001	501	501	501	401	201	201	201	201
a=0.1	100.	100,	50.	50.	50.	40	20*	20*	20*	201
0.2	100'	100'	50'	40'	50'	50'	40'	20'	20'	20'
0.3	100'	100'	50'	50'	40'	50'	50'	20'	20'	20'

Adapting Equation 25 as above, we obtain:

$$Cost = (0.5 + L (FC/100.))n$$
 (29)

where: L = feet per sample unit
n = sample size
FC = minutes to sample 100 feet (from regression
equation, Table 16)

and thus the curves in Figure 23 and 24. Figures 23 and 24 clearly indicate optimal sample unit sizes less than 100 feet for two of the densities graphed. The relationship between the density and optimal sample unit size (L) seems to be little effected by the precision levels as indicated in Table 18. Although the values of Table 18 reflect the true optimum sample unit size, often the effect of varying L over a wide range will have little effect on the overall time spent sampling (Figure 23: $\bar{X} = 50$). For other densities, the time savings can be appreciable (Figure 23: $\bar{X} = 100$; savings = 33%).

The necessary sample size (n) is conditional on the size of the sample unit selected. If apriori estimates of the field density are available from previous sampling dates or from preliminary sampling, Table 18 gives the optimum sample unit length (L). When such information is lacking, the lowest density of interest must be selected from Table 18. In either case, the estimated population variance can be calculated from the regression coefficients of Table 17 and then used in Equation 28 for calculation of the necessary sample size n.

If low precision estimation is adequate and the resultant sample size is less than 30 samples per field, it must be remembered that the properties of the Central Limit Theorem do not hold and normality

cannot be assumed. In that event the use of Chebyshev's Theorem (Steel and Torrie 1960) allows the estimation of confidence limits for any type of distribution.

Within Field Sampling for Age Specific Density

Within field density sampling was conducted ten times throughout the 1977 growing season. The first two sample periods (June 10 and June 14) revealed no observable onion maggot damage within the test field; therefore, samples were taken to estimate onion maggot density within stratum 1 (healthy onions). With the first observable onion maggot damage (June 23), sampling was initiated in strata 2-5. Tables 19 and 20 list the sampling phenology along with a data collection summary for each sampling period. The complete set of sampling data is listed in Appendix E. The healthy onion samples (stratum 1) are not listed in either Table 19 or 20 because only observations of 0.0 were recorded for every sampling date. Although no true means were established, some insight into the stratum density can be established using detectable survey techniques.

Since no observations larger than 0.0 were made, the actual fit of any probability density function cannot be tested, but the application of the poisson distribution is a reasonable assumption, because attacks on young virgin onions occur randomly (page 53) and as statisticians have long recognized, the poisson is the "rare events" distribution (Steel and Torrie 1960, and Sokal and Rohlf 1969).

DATE	MEAN	STANDARD ERROR	PERCENT DAMAGE*
6-10	0	0	0
6-14	0	0	0
6-23	42.1	10.90	2.8
6-30	56.9	11.10	3.8
7-7	60.8	10.80	4.1
7-21	69.8	12.50	4.7
7- 29	67.0	14.80	4.5
8-3	74.7	16.40	5.0
8-12	70.9	13.76	4.7
9-1	71.1	12.21	4.7

TABLE 19. Summary for the 100 foot plant damage sample taken throughout the 1977 growing season within a single test field in Grant, Michigan.

* Based on full stand of 15 onions per foot.

DATE	#CLUMPS SAMPLED	STRATA	n	LIFE STAGE	MEAN	VARIANCE	VAR/MEAN
<	-			_			4
6-23	5	2	193	E	0.0///	0.3325	4.28
				1	0	0	-
				2	0	0	-
				3	0.0104	0.0103	0.99
		2	26	P	0	0	-
		3	36	E	2.0556	14.5111	7.06
				1	1.0278	8.3706	8.14
				2	1.3056	5.5325	4.24
				3	1.166/	1.1/14	1.00
			70	P	0.1389	0.1230	0.88
		4	78	E	0.0461	0.2166	3.38
				1	0.0513	0.2051	3.99
				2	1.1/95	6.5910	5.88
				3	0.6538	1.2682	1.94
		r	•	P	0.2821	0.3350	1.18/5
c 20	6	5	220	None	Observed	-	-
6-30	б	2	229	E	0.0873	0.4046	4.03
				1	0	0	-
				2	0.0087	0.0087	1.00
				3	0.0480	0.0722	1.50
		2	20	P	0.0087	0.0087	1.00
		3	28	E 1	1.4211	5.7639	4.06
				1	0.2895	0.5896	2.04
				2	0.9211	4.0152	5.00
				3	1.0263	1.64/9	1.60
		٨	00	F	0.6055	0.7319	1.21
		4	00	1	0 0114	0 0114	1 00
					0.0114	0.0114	7 100
				2	0.1023	0.7365	7.199
				נ ם	0.1364	0.4180	3.00
		5	0	None	0.4432	0.3040	0.0224
7-7	•0	2	0	F		-	- 1 79
/-/	0	2		נ	0.0244	0.0435	1. 70
				2	0.0466	0.3996	1 00
				2	0.0049	0.0049	1.00
				Ð	0.0140	0.0143	1 00
		3		<u>।</u> न	0.0049	1 0567	5 16
		5		1	1 3600	10 3333	7 50
				⊥ 2	T.3000	TO.3533	2 01
				2	0.3200	1 1400	2.01
				כ ם	0.0400	1 0067	1 00

TABLE 20.	19 77	data	collection	summary	for	strata	2-5	in	the	Grant
	test	field	3.							

TABLE	20.	(continued)

DATE	#CLUMPS SAMPLED	STRATA	n	LIFE STAGE	MEAN	VARIANCE	VAR/MEAN
7-7	8	4	36	Е	0.0833	0.2500	3.00
		-		1	0	0	-
				2	0.1111	0.4444	4.00
				3	0.0278	0.0278	1.00
				P	0.6111	0.6803	1.11
		5	62	P	0.5000	0.6803	1.36
7-21	4	2	52	Е	0.1154	0.4962	4.30
				1	0	0	-
				2	0	0	-
				3	0.0385	0.7690	2.00
				Р	0	0	-
		3	9	Е	1.6667	6.5000	3.90
				1	0.6667	4.0000	6.00
				2	3.0000	22.0000	7.33
				3	0.4444	0.5278	1.19
				P	0.3330	0.2500	0.75
		4	5	Е	0	0	-
				1	0	0	-
				2	0	0	-
				3	0.2000	0.2000	1.00
				P	0	0	-
		5	56	P	0	0	-
7-29	1	2	20	E	0.1000	0.2000	2.00
				1	0	0	-
				2	0.5000	5.0000	10.00
				3	0.2500	0.6184	2.47
		-	-	P	0	0	-
		3	2	E	0	0	-
				1	0	0	-
				2	0	0	-
				3	0	0	-
		•	•	P	6.0000	2.0000	0.33
		4	9	E	1 0000	0	-
				1	1.0000	9.0000	9.00
				2	1.7800	20.4400	12.90
				3	0.4400	1.0278	2.34
		E	40	r P	2.0090	0.111U 1 7200	2.12
o_ c	n	5 2	43	r F	1.7200	4.7290	2.15
c-0	2	2	9	ட 1	0 2220	0 4440	2 00
				1 2	0.2220	0.4440	2.00
				2	0.0009	2 2500	1 25
				נ ק	1.00/0	2.2000	1.3J 5 69
				r	2.1110	TT.00TT	J.02

TABLE 20. (continued)

DATE	#CLUMPS SAMPLED	STRATA	n	LIFE STAGE	MEAN	VARIANCE	VAR/MEAN	
8-3		3	9	Е	0	0	_	
				1	0	0	-	
				2	2.0000	7.2500	3.63	
				3	1.3330	1.7500	1.31	
				Р	10.6667	181.5000	17.02	
		4	9	Е	0	0	-	
				1	0	0	-	
				2	0.7778	1.9444	2.50	
				3	0.6667	1.0000	1.50	
				P	10.8890	72.6111	6.67	
		5	43	Р	2.6512	21.8992	8.26	
8-12	1	2	35	Е	0	0	-	
				1	0	0	-	
				2	0	0	-	
				3	0.2000	0.6941	3.47	
				Р	0.1429	0.2437	1.71	
		3	10	Е	0	0	-	
				1	0	0	-	
				2	0	0	-	
				3	1.2000	4.4000	3.67	
				P	11.1000	122.3220	11.02	
		4	22	E	0	0	-	
				1	0	0	-	
				2	0	0	-	
				3	0.1818	0.2511	1.38	
• 1	2	~	2.2	Р	1.1213	28.8/45	3.74	
9-1	2	2	33	E	0.0910	0.2/2/	3.00	
				1 2	0	0	-	
				2	0	0	-	
				נ ת	0 2020	1 4062	-	
		2	15	r F	0.3939	1.4962	3.80	
		3	12	ב ו	1.2007	9.2095	7.27	
				2	1.6000	20 2142	8.02 11 20	
				2	1.8000	20.3143 A 3910	6 57	
				ק	11 0000	115 8570	10.53	
		Δ	30	F	11.0000	0	-	
		-3	30	ĩ	0	0	_	
				2	0	0	-	
				3	0.0667	0,1333	2.00	
				P	12,8670	41,5678	3.23	
		5	31	P	2.0645	18.0624	8.75	
			<u> </u>	-	2.0045	10.0024		

Assuming these data to be poisson distributed, the probability (P(r)) of finding r individuals per sample is given by Pielou (1977) as:

$$P_{(r)} = \frac{\hat{x}^{r}}{r!} e^{-\hat{x}}$$
(30)

where: $\hat{\mathbf{x}} = \mathbf{expected}$ mean

e = base of the natural logarithms

For detection purposes, this function can be rewritten to calculate the probability (P) of finding at least one organism, probabilistically one minus the probability of finding zero organisms in N samples (Ruesink and Haynes 1973).

$$P = 1 - e^{-\hat{X}N}$$
(31)

Lampert (1976), solving Equation 31 for N (Equation 32), was able to directly calculate the maximum possible value of the population mean for any given sample size (N) and the level of confidence (P).

$$\mathbf{x} = \frac{-\ln\left(1 - \mathbf{P}\right)}{N} \tag{32}$$

Using Equation 32 with a 95% level of confidence, the maximum possible value of the stratum 1 mean (N = 100) is 0.03. The true value of the mean may lie well below this level, but no tighter upper limit can be established without drastically increasing the sample size (N): there-fore stratum 1 is considered to have a maximum possible density of 0.03 onion maggots per onion thoughout the entire season.

The remaining strata (2-5) each contained non-zero data elements, thus the computation of means and variances was trivial. Each stratum was analyzed separately for the immature stages (egg-pupa) as well as for the cumulative immature population. Analysis of variance was performed on the logarithmic transformation of these data for each sampling

data and the pooled sets to determine if the assigned grades truly represented meaningful strata. Significant differences were found among the strata in every analysis with the pooled multiple range test (Student-Newman-Keuls: $\alpha = 0.05$) for the cumulative immature population showing complete separation of the class means. Table 21 gives the stratum means and the multiple range tests of the pooled data for each life stage and cumulative immature population. Specific life stages are found occurring more frequently in some strata than in others (i.e., first instar larvae rarely occur in strata 1, 2, 4, and 5, while typically abundant in stratum 3). Since strata definitions were based on the evolution of damage through time, it was expected that these life stages would require different levels of stratification. Of significant importance is the stratum loading of the egg stage, whose density is approximately 20 times greater in stratum 3 (damaged onions) than in any other strata. The stratum loading indicates an ovipositional preference for previously damaged onions and is believed to be a key factor in the population dynamics of this insect.

As the age structure of the population changes throughout the season, the expected differences between stratum densities are not always apparent due to low levels of specific life stages. For example, the sample taken on July 21 revealed no significant differences between any stratum due to the recent emergence of the second generation adults (Figure A-3). Since individual sampling dates all possess bias due to the existing age structure, the data sets pooled across sampling dates are believed to best represent the stratum loading for

LIFE STAGES	STRATA	MEANS & GROUPINGS
Eggs	1	0.0300 a*
	2	0.0646 a
	3	1.2946 b
	4	0.0324 a
	5	0 a
First Instar	1	0.0300 a
	2	0.0162 a
	3	0.6822 b
	4	0.0567 a
	5	0 a
Second Instar	1	0.0300 a
	2	0.0283 a
	3	1.0465 b
	4	0.5182 c
	5	0 a
Third Instar	1	0.0300 a
	2	0.0606 a
	3	1.0078 b
	4	0.3239 c
	5	0 a
Pupae	1	0.0300 a
	2	0.0363 a
	3	2.1163 b
	4	1.5263 c
	5	1.2026 c
Cumulative	1	0.0300 a
Population	2	0.2059 b
-	3	6.1473 c
	4	2.4576 d
	5	1.2026 e

TABLE 21. Means and multiple range tests (Student-Newman-Keuls) for each life stage by strata (1-5) calculated from sampling data pooled across the entire growing season.

*Means with the same letter are not significantly different (P = 0.95).

each life stage and their cumulative total. Even though sampling precision varies somewhat due to the population's shifting age structure, stratum weighing, if based on yearly averages, should drastically increase the precision over simple random sampling.

Cochran (1963) gives the mean of a stratified sample as:

$$\bar{\mathbf{Y}}_{\text{strat}} = \mathbf{W}_{h} \bar{\mathbf{Y}}_{h}$$
(33)

and the variance of the mean as:

$$\operatorname{Var}(\bar{Y}_{strat}) = \frac{\left(\sum_{h=1}^{\bar{\Sigma}} w_h S_h\right)^2}{n_h}$$
(34)

where: L = number of strata W_h = proportion of stratum h $(\frac{Nh}{N})$ n_h = sample size of stratum h n = total sample size \overline{Y}_n = mean of stratum h S_h = standard deviation of stratum h

Setting the standard error of the mean equal to a fixed percentage of the mean (α) we obtain Equation 35.

n =
$$(Z_{\alpha/2})^{2} \left(\frac{\sum_{h=1}^{L} w_{h} s_{h}}{(\alpha \bar{x})^{2}}\right)^{2}$$
 (35)

The optimal allocation of n for each stratum (n_h) , assuming equal sampling costs per stratum, is given by Cochran (1963) as:

opt
$$(n_h) = n \left(\frac{w_h S_h}{\Sigma S_h}\right)$$
 (36)

The calculation of the total number of samples n and its allocation between strata (n_h) is dependent on the stratum mean (\bar{y} STRAT), its standard deviation (S_h) , and its size as a proportion of the total sample universe (W_h) . When sampling apriori knowledge of W_h can be easily gathered using damage sampling techniques similar to those presented on page 41, but apriori knowledge of both μ and S² is expensive and time consuming. Instead of time specific estimates, predetermined expected values can be used. Substituting yearly averages for expected values is one possible solution to this problem and will be used here to demonstrate the increased efficiency of sample stratification. If sampling is done frequently through time, a more efficient method would be to use sample estimates of \overline{y}_h and S_h^2 calculated from the most recent sampling date.

To evaluate the effects of within field aggregation on sampling procedures, analysis of variance was also used to test between clump differences for each life stage. Analyses were made on the stratified and unstratified data sets. As the total number of analyses exceeded 50 tests, the third instar results which clearly represent the trend seen in every life stage will be presented. In the unstratified analysis, significant differences were found in the per onion density of each life stage between damage clumps. Inclusion of the onion strata in the analysis (two-way ANOVA life stage x strata x clump) clearly showed that between clump differences were due to the onion strata and not the physical clumps. Table 22 shows the results of five two-way analyses of variance for the third instar population. In all cases, using the above stratification scheme, the between clump differences are non-significant. Clumps of damage can be described as being composed of varying numbers of onions belonging to each of these strata, and their use as control variables clearly helps eliminate excessive variation between areas.

DATE	SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARES	F	SIGNIFICANCE
6-23	Clump	1.180	4	0.295	1.741	0.141
	Strata	27.068	2	13.534	79,900	0.001*
	Error	50.816	300	0.169		
	-1		-			0.026
6-30	Clump	0.810	5	0.162	1.367	0.236
	Strata	14.513	2	7.257	61.245	0.001*
	Error	41.115	347	0.118		
7-7	Clump	0.518	7	0.074	1.201	0.302
	Strata	4.231	3	1.410	22.912	0.001*
	Error	19.514	317	0.062		
7-21	Clump	0.037	3	0.012	0.265	0.851
	Strata	1.210	3	0.403	8.547	0.001*
	Error	5.429	115	0.407		
8-3	Clump	0 598	1	0 598	2 913	0.093
	Strata	10,184	3	3,361	16.374	0.001*
	Error	13.343	65	0.205	10.3/4	0.001

TABLE 22.	Anal	lysis	of	variance	table	for	third	instar	larvae	by	clump
and strata.											

*P < 0.01

The variance of the mean, for the third instar larvae and the total immature population, was calculated based on simple random sampling, stratified proportional sampling, stratified optimal sampling, and yearly average stratified sampling.

To estimate sample allocation based on yearly averages, log variance-log mean regressions were used to estimate the variance to mean relationships for each immature life stage and the cumulative immature population for each stratum. For some combinations, the regressions of the various life stages per stratum showed no statistical differences, the data then being pooled and a more generalized model fit (Figure 25: variance to mean relationship of eggs, first and second instars in strata 2 and 3).

Table 23 lists the regression statistics for each life stage by stratum, adjusted as suggested by Bliss (1967). The yearly means (Table 21) can be used in their respective regression equations of Table 23 to estimate their expected variances, which are in turn used in Equation 36 for the determination of sample allocation between strata (n_h) . These values, along with W_h (calculated from Tables 19 and 20) and the sample estimates of \overline{y} STRAT and S² STRAT were used in Equation 34 to calculate the actual variance of the mean stratified by the yearly averages. The results (Tables 24 and 25) are presented in terms of the standard error to mean ratio for easy comparison. As the tables indicate, stratification is always more efficient than simple random sampling, and stratification based on yearly averages is always better than proportional stratification, but rarely approaches the precision of optimal allocation. As mentioned earlier, preliminary



FIGURE 25. Variance to mean relationship of eggs, and first and second instars in onion strata 2 and 3.
LIFE STAGES			RATUM	۱ ۱ ۱ ۱ ۱ ۱ ۱
Egg Stage	$y = 10.5x^{1.44}$ $r^2 = 0.855$	$y = 5.75x^{2.2}$ $r^{2} = 0.86$	*	*
First Instar	*	$y = 5.75x^{1.2}$ $r^2 = 0.86$	×	*
Second Instar	*	$y = 5.75x^{1.2}$ $r^2 = 0.86$	$y = 5.75x^{1.2}$ $r^2 = 0.86$	*
Third Instar	$y = 2.72x^{1.1}$ $r^2 = 0.917$	$y = 2.72x^{1.1}$ $r^2 = 0.917$	$y = 1.0x^{1.7}$ $r^2 = 0.926$	*
Pupal Stage	*	$y = 1.91x^{1.5}$ $x^{2} = 0.976$	$y = 1.91x^{1.5}$ $r^{2} = 0.976$	$y = 3.0x^2 \cdot ^0$ $x^2 = 0.94$
Cumulative Population	$y = 5.93x^{1.0}$ $r^{2} = 0.938$	$y = 1.88x^{1.7}$ $r^2 = 0.80$	$y = 2.84x^{1.4}$ $r^2 = 0.95$	$y = 3.0x^{2.0}$ $r^2 = 0.94$

Regression equations for mean (x) - variance (y) - relationship by stage for each stratum. TABLE 23.

* Event too rare to estimate.

DATE	$\sigma^2_{\overline{x}}$	σ_/x x
6-23-77		
SR	0.000211	0.28
Prop	0.000161	0.24
Ave	0.000112	0.20
Opt	0.000064	0.15
6-30-77		
SR	0.000147	0.31
Prop	0.000129	0.29
Ave	0.000095	0.25
Opt	0.000054	0.19
7-7-77		
SR	0.000366	0.45
Prop	0.000243	0.36
Ave	0.000108	0.24
Opt	0.000043	0.15
7-21-77		
SR	0.000246	0.36
Prop	0.000220	0.34
Ave	0.000190	0.32
Opt	0.000077	0.203
7-29-77		
SR	0.000938	0.49
Prop	0.000661	0.41
Ave	0.000556	0.37
Opt	0.000128	0.18

TABLE 24. Comparison of third instar sampling precision using simple random (SR), proportional stratification (Prop), yearly average stratification (Ave), and optimal stratification (Opt) sampling in strata 1-5.

DATE	$\sigma^2_{\overline{x}}$	σ / \bar{x}
8-3-77		
SR	0.002768	0.43
Prop	0.000576	0.20
Ave	0.000223	0.12
Opt	0.000084	0.08
8-12-77		
SR	0.000943	0.46
Prop	0.000793	0.43
Ave	0.000427	0.31
Opt	0.000135	0.18
9-1-77		
SR	0.000939	0.73
Prop	0.000865	0.71
Ave	0.000415	0.49
Opt	0.000229	0.36

DATE	$\sigma^2_{\overline{\mathbf{x}}}$	σ_/x x
6-23-77		
CD	0 002150	0.35
Bron	0.001150	0.35
Ave	0.000230	0.25
Opt	0.000080	0.07
6-30-77		
SR	0.000901	0.30
Prop	0.000487	0.22
Ave	0.000193	0.14
Opt	0.000064	0.08
7-7-77		
SR	0.003141	0.31
Prop	0.002207	0.26
Ave	0.000567	0.13
Opt	0.000126	0.06
7-21-77		
SR	0.014377	0.53
Prop	0.009540	0.43
Ave	0.001840	0.19
Opt	0.000410	0.09
7-29-77		
Sr	0.036990	0.31
Prop	0.025760	0.26
Ave	0.008090	0.15
Opt	0.001598	0.06

TABLE 25. Comparison of total immature population sampling precision using simple random (SR), proportional stratification (Prop), yearly average stratification (Ave), and optimal stratification (Opt) sampling in strata 1-5.

DATE	$\sigma^2_{\overline{x}}$	σ_/x x
8-3-77		
SR	0.117968	0.29
Prop	0.060899	0.21
Ave	0.013086	0.10
Opt	0.003210	0.05
8-12-77		
SR	0.048080	0.34
Prop	0.021790	0.23
Ave	0.003540	0.09
Opt	0.000729	0.04
9-1-77		
SR	0.062014	0.31
Prop	0.016720	0.16
Ave	0.002783	0.06
Opt	0.000574	0.03

sampling to estimate S² STRAT or utilization of data from recent sampling periods could more efficiently allocate the samples between strata, thus approaching the precision achieved with optimal sample stratification.

The allocation of samples is heavily weighted toward stratum 1 (approximately 80% for proportional allocation and 70% for average allocation). The large area covered by this stratum necessitates a high proportion of the samples allocated even though the mean value is always low (0.03). The calculation of n, total samples $(\Sigma n_{\rm h})$, for a moderate level of precision ($\alpha = 0.2$) yields extremely large values (approximately 2,000 for third instars and 500 for the total immature population). Approximately 70-80% of this sample is allocated to find extremely rare individuals in stratum 1 where no non-zero observations were recorded all season and a "maximum" possible density is known to be below 0.03. Due to the extremely low density found within this stratum and its effect on the overall sample size, the sampling statistics will again be calculated with the stratum 1 onions framed out of the sample universe. Tables 26 and 27 list the variance of the sample mean and the standard error to mean ratio of the samples for the third instar larvae and the total immature population respectively. In most cases the standard error to mean ratio is reduced, but more importantly, the number of samples necessary to predict the population mean of strata 2-5 at the same level of precision (α = 0.2) was reduced approximately 50%.

Using density estimates calculated only from strata 2-5 and then weighing those estimates by the proportion of the total universe

 $\sigma^2 \over {f ar x}$ σ_/x̄ x DATE 6-23-77 SR 0.00210 0.15 0.13 Prop 0.00150 Ave 0.00080 0.09 0.00030 0.06 Opt 6-30-77 SR 0.00130 0.09 0.07 Prop 0.00100 0.06 Ave 0.00070 Opt 0.00020 0.03 7-7-77 0.41 SR 0.00102 0.36 Prop 0.00080 Ave 0.00051 0.29 Opt 0.00018 0.17 7-21-77 SR 0.000747 0.50 Prop 0.00060 0.45 Ave 0.00050 0.402 0.00030 0.312 Opt 7-29-77 0.51 SR 0.00440 Prop 0.00410 0.48 0.47 Ave 0.00400 Opt 0.00090 0.22

TABLE 26.	Comparison of third instar sampling precision using simple
	random (SR), proportional stratification (Prop), yearly
	average stratification (Ave), and optimal stratification
	(Opt) sampling in strata 2-5.

DATE	$\frac{\sigma^2}{x}$	σ_/x x
8-3-77		
SR	0.01281	0.24
Prop	0.00940	0.21
Ave	0.00930	0.20
Opt	0.00120	0.07
8-12-77		
SR	0.01031	0.40
Prop	0.00900	0.37
Ave	0.00770	0.35
Opt	0.00190	0.17
9-1-77		
SR	0.00670	0.73
Prop	0.00610	0.69
Ave	0.00200	0.40
Opt	0.00090	0.27

TABLE 27. Comparison of total immature population sampling precision using simple random (SR), proportional stratification (Prop), yearly average stratification (Ave), and optimal stratification (Opt), sampling in strata 2-5.

DATE	$\sigma^2_{\overline{x}}$	
		A
6-23-77		
CD	0 030200	0 13
Prop	0.018900	0.13
Ave	0.010400	0.08
Opt	0.003530	0.05
6-30-77		
CD	0.010240	0.14
SR	0.010340	0.14
Ave	0.004150	0.10
Opt	0.001365	0.05
ope	0.001303	0.00
7-7-77		
SR	0,015250	0.21
Prop	0.011235	0.18
Ave	0.005624	0.13
Opt	0.001595	0.07
7- 21-77		
SR	0.061100	0.49
Prop	0.041366	0.40
Ave	0.012673	0.23
Opt	0.004250	0.13
7- 29-77		
SR	0.235670	0.23
Prop	0.195450	0.21
Ave	0.180640	0.20
Opt	0.045000	0.10

DATE	$\sigma^2_{\overline{x}}$	σ_/x x
8-3-77		
SR Prop Ave Opt	0.972525 0.680664 0.578580 0.179570	0.17 0.15 0.13 0.07
8-12-77		
SR Prop Ave Opt	0.491043 0.300240 0.211651 0.055690	0.17 0.14 0.11 0.06
9-1-77		
SR Prop Ave Opt	0.656786 0.279454 0.220135 0.062090	0.12 0.08 0.07 0.04

they represent, allows density estimates of the total universe to be made. Figure 26 shows the per onion density of both onion maggot pupae and the cumulative immature population in the Grant, Michigan test field. Abundance curves for the earlier life stages will not be presented because the sampling interval used in this study was too large to estimate their age specific densities. This interval does not effect the point estimation of density or the methods presented in this section, it merely eliminates the ability to evaluate total incidence through time. To make abundance curves for the earlier life stages, the sampling interval must be reduced at least to the length of the developmental stadium in question (see Appendix A on temporal distribution for developmental data).

Biological Monitoring

Periodic assessment of the biological components (host plant, pests, parasitoids, etc.) within an agroecosystem is essential for the development and implementation of crop management programs. Crop loss assessment as well as effective pest management systems are two such programs that are highly dependent on effective biological monitoring schemes.

Biological monitoring programs are typically goal oriented, with a given objective or set of objectives firmly defined at the onset of the project. To meet such objectives, which can be quite broad in scope, it may be necessary to utilize a series of specific sampling techniques simultaneously or sequentially through time. Sampling methodology is usually very specific in orientation and statistical interpretation. Coordination in the use of such techniques and trade-offs





between their breadth, precision, and economic costs must be closely evaluated in terms of the objectives of the overall biological monitoring program.

Construction of a biological monitoring program for onion maggots in Michigan could take innumerable forms depending on the specific objectives at hand. The possibilities range from small plot damage estimation to regional density estimates of the insect itself, both of which can be accomplished using variations of the same sampling techniques.

For pest management purposes, the needs of an immature onion maggot monitoring program are extensive and provide an excellent example of how several sampling techniques can be structured to work towards common goals.

In Michigan and other northern states, onion production is primarily limited to organic soils. As formation of these soils typically occurs in old lake and river beds, (Davis and Lucas 1959) its geographical distribution is highly aggregated, thus producing similar patterns in muck grown crops such as onions. A characteristic organic soil production region is the Rice Lake area near Grant, Michigan. This muck area, an old lake bed, contains approximately 9 square miles of organic soil and is farmed by numerous growers. Figure 2 provides discrete boundaries of the muck area and shows those field which were planted in onions during the 1976 and 1977 growing season.

The onion maggot, an obligate pest of <u>Allium</u> spp., is found attacking onions throughout the Grant growing region. Few, if any,

<u>Allium</u> spp. are present in the surrounding areas; therefore, the onion maggot population is primarily limited to commercial onion fields.

As adjacent fields are controlled by different owners, their management policies, including onion maggot control, are usually independent of one another. In contrast, onion maggot damage seems to occur over a broader area, being unrestricted by actual field boundaries. Figures 27 and 28 are contour maps showing second generation onion maggot plant damage over the entire Grant region for 1976 and 1977, respectively. The maps were constructed using the data as listed in Appendix B with contour lines drawn through points of equal damage. Each contour line represents the number of injured plants per 1 meter section of row (approximately 23 onions per meter). These maps indicate onion maggot damage as a regional problem with adjacent fields showing similar density levels. The adult onion maggot is highly mobile (Loosjes 1976); therefore, movement between surrounding fields needs to be considered when designing and executing onion maggot management strategies.

Metcalf and Luckman (1975) stress the need for development of pest management systems which operate at the ecosystem level, taking into account the total pest population, its full effective range, and other major factors affecting its survival and development. These principles are presently being researched at Michigan State University (Haynes et al. 1977) and it has become obvious that to effectively develop management strategies for the onion maggot, its density throughout the total region is of key importance. In Grant the area necessary for consideration is clearly the entire nine square mile muck region.



FIGURE 27. Contour map of onion maggot plant damage in Grant, Michigan 1976.



FIGURE 28. Contour map of onion maggot plant damage in Grant, Michigan 1977.

The true onion maggot densities of every onion field within a region would give complete knowledge to base management decisions on. In reality, the absolute densities are impossible to acquire, thus sampling estimates must be substituted. As previously described, data collection for estimating the absolute immature onion maggot density is quite expensive and quickly becomes prohibitive when sampling multiple fields.

An alternative approach to intensive sampling for absolute densities in every field is the construction of a hierarchical sampling system. By using a less comprehensive sampling method initially, the total sampling universe can be divided into portions of variable interest. These subunits can then be dealt with in more specific terms without impinging unnecessary methods, thus cost, on the total universe of concern.

Using plant damage as an indicator of actual immature onion maggot densities, a regional survey involving every field within a region, can be used to identify fields above and below a predetermined critical density level. Field level plant damage sampling techniques give the number of subsamples per field necessary for precision estimation at the field level. Extraction of 10-100 foot plant damage subsamples per field allows a damage density as low as 3% to be estimated with a precision range of approximately 3.0. The exact time involved in completion of a regional sampling program is dependent on the size of the region and can be estimated from Equation 25. Using ten 100 foot

than one hour, thus requiring approximately 25 man hours to sample a growing area the size of Grant, Michigan.

Fields revealing damage levels below the level of interest should then be eliminated from the sampling universe. Those fields showing higher densities should be more closely evaluated using the extensive sampling techniques for estimation of actual immature onion maggot densities (see pages 80 to 102).

A total biological monitoring program for onion pest management or even for onion maggot control may have many more components than the above example, as many more biological entities are sure to be involved (Haynes et al. 1977). With the addition of more components, the costs of the monitoring system quickly inflates, thus coordination or structuring of the system to meet multiple objectives simultaneously is manditory.

Biological monitoring is much more than a simple sampling procedure. It is a management system divised for optimization of specific biological data collection given standard sampling techniques, restricted resources, and a set of closely defined objectives. SUMMARY

The spatial distribution of the immature onion maggot was evaluated at various geographic levels. Aggregation or clumping was found to predominate from the regional distribution of plant damage between fields down to the distributional pattern of the maggot within damaged onions. The negative binomial frequency distribution was utilized to describe the majority of the observed sampling data. Although the NBD typically fit quite well, no K_c or common aggregation coefficient was indicated above the within clump level. A common K was found for the actual onion maggot counts within areas of damage, but it is not known if the pattern holds between fields.

Ovipositional attraction was tested and preference for rotting and/or rotting and infested onions was found to exist. These experimental results are heavily supported from independent field data which shows a 20-fold increase in egg density on previously damaged onions over adjacent healthy onions. This behavioral biology in combination with the spatial pattern of initial plant damage is felt to play a key role in the mode and the distribution of onion maggot attack throughout the season.

Sampling techniques were developed for estimation of both onion maggot induced plant damage and actual age specific onion maggot densities. Two stage sampling techniques were utilized for determination of the optimal sample unit size and the optimal number of samples to

be drawn for precision estimation of regional onion maggot plant damage. Sampling costs, evaluated in terms of time units, were also measured and incorporated into the overall analysis. A similar analysis followed for determination of the optimal sampling methods for within field plant damage sampling. As with the preceeding section, sample unit lengths, sample sizes, and sampling costs were all evaluated.

Stratified random sampling techniques were used in the development of sampling methods for age specific onion maggot density estimation. Stratification was based on visual plant damage symptoms produced by onion maggot larvae feeding in the onion bulb. A comparison of age specific sampling using simple random sampling, proportional stratification, yearly average stratification, and optimal stratification clearly showed the utility of the techniques: sampling precision was increased while it reduced the number of samples actually extracted.

Development of more comprehensive biological monitoring programs was discussed in general terms, stressing the differences between standard sampling methodology and the more inclusive objectives of a biological monitoring program. An example program for regional onion maggot density estimation, using a hierarchical sampling scheme, was also presented.

This study was designed to address several questions relating to immature population monitoring of the onion maggot. It is hoped that these findings will serve future researchers in their studies pertaining to the population biology and eventually the population management of this insect pest.

APPENDICES

All Data Files in the following Appendices can be found in a User Permanent File, 7-track tape, VRN=UP1200.

APPENDIX A

Temporal Distribution

The onion maggot is multivoltine with a variable number of generations found throughout its geographic distribution. In Michigan, typically three generations per year are noted. The females exhibit a cyclic ovipositional pattern and remain gravid over an extended period of time (Missonier and Stengel 1966). This extended ovipositional activity allows an overlapping of life stages and under some conditions an overlapping of generations.

Although the temporal distribution is not the main thrust of this study, population phenology is important in various types of entomological studies. It is believed that the inclusion of such information will aid in future interpretations of this study and will develop a better understanding of the onion maggot biology as a whole.

Developmental Zeros and Heat Accumulation Requirements:

Numerous observations concerning the developmental rates of \underline{H} . <u>antiqua</u> have been made under a variety of laboratory and field conditions. Ellington (1963) reviewed the literature concerning this area and tabulated the results. Finding the existing data inconsistent, Ellington conducted laboratory experiments to define the developmental rates for eggs, larvae, pupae, and preovipositional adults at various

constant temperatures. The data presented by Ellington was in the form of days for development for a series of temperatures $(50^{\circ}, 60^{\circ}, 70^{\circ}, 80^{\circ}, \text{ and } 90^{\circ}\text{F})$.

Additional developmental data was obtained through the University of Guelph (Ritchey, personal communication 1977). The data consisted of mean days for development of the egg, the first, second, and third instars and the pupal stage given six temperatures $(50^{\circ}, 54.5^{\circ}, 59^{\circ},$ $65.5^{\circ}, 68^{\circ}$, and 77° F).

To determine degree-day accumulations it is necessary to first establish lower limit thresholds, below which no development occurs. Threshold determination is typically done by plotting percent development per day over a range of temperatures, finding the point at which the regression line crosses the x axis, and defining that point as the lower threshold.

The accuracy of this method depends on two major assumptions: 1) that the data (original or transformed) is linear, and 2) that the test temperatures include or approach the suspected minimum developmental threshold.

Both data sets used a low temperature of $50^{\circ}F$ (10° higher than the suspected threshold base). Since the range of extrapolation is large, care must be taken in the use of regression analysis. Regression analysis was performed on the linear portion of the data to approximate the base temperature (Figure A-1). Another method, standard error determination (Casagrande 1971) was also used to estimate the base temperature. This method uses several temperatures bracketing



FIGURE A-1. Regression method for determination of developmental base temperature for third instar larvae.

the suspected true base temperature for calculation of degree-day accumulations. Standard errors are calculated for each base temperature (Figure A-2). The minima of the standard error function determines the base temperature that best fits the given data set.

The short developmental stadiums for the egg, first instar and second instar necessitate very short periods of time between samples if the data is to be used for threshold determination. Ellington's daily sampling was not precise enough to use for such calculations. The longer third instar and pupal stadium did provide suitable data for this analysis. Table A-1 presents this data along with the mean and its 90% confidence limits.

Mean degree-day accumulations for the egg, larval (first, second, and third instars), pupal, and preovipositional adult stages are listed in Table A-2 along with their sources. Ellington's data for instar 1 and instar 2 was omitted because of low sampling frequency.

Population Maturity

Fulton (1973) discusses several methods for evaluating population age distributions or maturity through time. The weighted mean instar (WMI) maturity scale was extremely useful as the population age structure is represented as a single number. Weighted mean instar is calculated as in Equation A-1.

$$WMI = \frac{t}{i=1}^{P} i N_{i} / \frac{t}{i=1}^{P} N_{i}$$
(A-1)

where: P_i = proportion of total developmental stadium spent in life stage i N_i = number of individuals in life stage i t = number of life stages being evaluated



FIGURE A-2. Standard error method for determination of developmental base temperature for second and third instar larvae.

Using U. of Guelph's Data	Third Instar	Pupae
Linear regression	39.0	42.1
Standard error analysis	39.5	41.0
Using Ellington's Data		
Line ar re gression	37.5	37.0
Standard error analysis	36.0	38.0
	$\bar{x} = 38.76$	s = 2.06
	$s_{x} = 0.728$	t _{90%} = 1.86
\bar{X} with 90% confidence limits	38.76 ±	1.37

TABLE A-1. Developmental base temperatures of third instars and pupae.

Mean degree-day requirements (base = 39⁰F) for various life stages of the onion maggot. TABLE A-2.

MEAN 90.00 67.00 160.00 290.00 550.00 185.0 $\frac{5}{X}$ 8.48 3.11 4.43 24.05 19.17 25.2		EGG ^B	lst INSTAR ^G	2nd INSTAR ^G	3rd INSTAR ^B	PUPAE ^B	P.O. ADULTS ^E
$S_{\overline{X}} = 8.48$ 3.11 4.43 24.05 19.17 25.2	MEAN	90.00	67.00	160.00	290.00	550.00	185.0
	s. X	8.48	3.11	4.43	24.05	19.17	25.2

B = University of Guelph and Ellington (1963)

G = University of Guelph

E = Ellington

,

Computation of WMI for the immature onion maggot population (0 = E, 1 = first instar...4 = pupa) from the data collected in Grant, Michigan is plotted along with the mean adult activity trap catch from the same area (Figure A-3).

Adult population phenology has been evaluated using degree days by several researchers (Eckenrode et al. 1975, Libby unpublished, and Vail unpublished) and has been suggested as a method to help time adult control measures (Eckenrode et al. 1975). These studies, conducted in New York and in Michigan, report similar degree-day requirements for peak adult flight activity (Table A-3).

Although the heat accumulation between these peaks corresponds closely with that necessary to complete a full generation, care must be taken when predicting second and third generation emergence. This method does not account for major population time shifts due to mortality. Figure A-4 shows the expected adult activity peak (arrows) using the degree-day model of Table 21 (Michigan values). As the figure clearly indicates, large deviations from the expected peaks can be noted. This deviation from the expected is thought to have been caused by high immature mortality early in the growing season. Larval damage was expected as early as 700 degree-days (initial emergence and preovipositional period) but was not encountered until 1650 degreedays, well in excess of the required accumulation. The hot dry conditions which persisted through the early growing season, in combination with the granular insecticide placed at planting, were presumably









LOCATION	lst GENERATION PEAK	2nd GENERATION PEAK	3rd GENERATION PEAK
New York base = 40 [°] F	710	1900	3150
Michigan base = 39 ⁰ F	670	1710	2920

TABLE A-3. Average degree-day accumulation for adult onion maggot activity peaks from New York and Michigan. (Eckenrode et al. 1975, and Vail unpublished). responsible for the high mortality rates. Shifting the expected second and third generation peaks by this 900 degree-day deviation (stars) explains the majority of the observed deviation.

In summary, phenology models which operate on developmental rates exclusively must be used with caution; critical deviations from the expected are possible. With the inclusion of environmental mortality or on-line monitoring such models could produce more reliable results.

APPENDIX B

Introduction

Current onion maggot control strategies consist of a granular soil insecticide at planting for control of larvae and directed foliar sprays for control of the adult flies. Michigan recommendations (Cress et al. 1976) call for one of three currently registered granular soil insecticides (Dansanit, Dyfonate, or Ethion) to be applied at planting. In addition to these recommendations a warning was issued which states:

> Dansanit has given erratic control for the past year or two, particularly in the Grant area. Growers are advised to use maximum rates and correct applications.

Dansanit gave spotty control in several fields which were composed of various mixtures of Martisco, Houghton, Edwards, Deford, and Tawas muck soils (soil types determined from Mokma and Whiteside 1973). Although the damage was not quantified within or between fields, local onion growers and county extension agents felt that a significantly higher amount of onion maggot damage was found in connection with tiled drainage ditches and fields high in marl content. Edwards, Martisco, and Houghton mucks are all found overlaying a marl base. Marl, a highly alkaline material, is also found in areas of the Grant swamp. Fields composed chiefly of Martisco mucks (marl less than 16" from the soil surface) are usually avoided for onion production, but both Edwards-Martisco combinations (soil type E, Mokma and Whiteside

1972) and Houghton (HM) mucks are used extensively in Grant, Michigan for onion production.

The fields containing the marly drainage ditches in question were composed mainly of Edwards and Houghton mucks (marl 16" to 54" from soil surface). These tile lines were visually apparent in the field and appeared as whitish-gray strips 3 to 4 feet wide and extending the majority of the field's length. The color differential is due to the calcium carbonate particulate matter found within the strips. The material was lifted from the underlying marl base at the time of tile installation and was mixed throughout the trench backfill.

Speculation by both Dr. Don Cress, vegetable extension entomologist (Michigan State University) and Bob VanKlompenberg, district extension horticulture agent, suggests that the increased alkalinity within these marly strips causes an acceleration in the chemical degradation of the acidic reacting insecticides. An acceleration of the chemical breakdown could account for increased onion maggot survival in such areas, thus explaining the 1974-75 observations.

Methods

A project was designed in the spring of 1976 to test the hypothesis of early chemical degradation in high alkaline tile line ditches using population damage as an indicator. The experimentation was conducted in the Rice Lake muck area near Grant, Michigan where many of the initial observations concerning this hypothesis were first noted.

In 1976, the initial year of this project, Dansanit was removed from the market in the formulation registered for use in onion maggot
control. Most growers replaced Dansanit was another organophosphate insecticide, Dyfonate. Dyfonate was never cited in the 1974-75 observations of damage in marly soil. However, because the chemical reaction of the two insecticides in the soil is thought to be similar, it was felt that this study should continue (Cress personal communication 1976).

Within Field Analysis

A field in section 10 of Grant Township (Field #10, Figure B-1) which was composed primarily of Houghton muck, was selected for the within field experimentation. The field was chosen for three reasons: 1) the field was noted in 1975 as having moderately high damage levels from the onion maggot with a substantial over-wintering population known to exist for the 1976 growing season, 2) some of the preliminary observations concerning the hypothesis in question came from the adjoining fields, and 3) the grower was willing to allow the removal of onions from his field for sampling purposes.

The field was tiled in a north-south direction with a drainage canal on the southern parameter of the field. Existing tile lines could easily be located. As expected, the location of the tile lines coincided with the whitish-gray marl streaks visible in the field.

The onions (downing yellow globe) were planted parallel to the drainage tile extending north from the canal approximately 1/4 mile. The onions were planted in six foot bands consisting of eight rows per band with a 1 foot tractor break between each band. A broadcase application of 300 pounds per acre of potash was placed before planting



and then supplemented by a within furrow application of an 8-32-16 fertilizer mix with 3% Manganese at the rate of 600 pounds per acre. Dyfonate was also applied as a within furrow application at the rate of 15 pounds per acre.

Two sample plots were laid out with respect to tile line location and areas of the field. Plot A was an onion band exactly overlaying an existing marly tile line, while plot B was equal distance from two such lines, thus making a nearly independent area with respect to the marly areas. Both plots were 200 feet in length and were kept 200 feet away from the edge of the field to avoid any edge effect in the distributional pattern of the maggot.

Ten one-row meter long samples of onion plants were randomly removed from each plot four times during the growing season. These plants were examined for onion maggot damage and the percent damage was calculated. In addition to the plant damage samples, ten soil samples were collected within each plot at the time that significant damage was first noted (July 1, 1976). These samples were submitted to the soil testing lab on campus where the analysis was performed. The soil parameters measured were pH, phosphorus, potassium, calcium, and magnesium.

Between Field Analysis

Between field sampling was also carried out in connection with a regional monitoring program. The objective was to compare field damage estimates with field soil types as given by Mokma and Whiteside (1973). The soil types analyzed were: 1) MF/CM (muck overlaying shallow sand), 2) CM (muck 16" to 51" deep overlaying sand), 3) E (Martisco-Edwards muck 0" to 16" deep overlaying marl), and 4) HM (Houghton muck 16" to 51" deep, overlaying marl). For detailed descriptions of each soil type (MF, CM, E, and HM) see Mokma and Whiteside (1973).

Twenty three fields were sampled in 1976, and 17 fields were sampled in 1977 (see Figure B-1). Fifty random samples (1 meter in length) were taken in each field. The number of damaged and healthy onions in each sample was recorded along with notes concerning any special observations (i.e., occurrence of other diseases, special soil conditions, heavy wind damage, etc.).

Results

Within Field Analysis:

The sample results from the within field damage were analyzed as paired sets through time. The null hypothesis $H_0: \mu_A = \mu_B$ with the alternative hypothesis $H_1: \mu_A \neq \mu_B$ was tested for each sampling date. The results of these comparisons are in Table B-1. The null hypothesis ($H_0: \mu_1 = \mu_2$) was easily accepted for every sampling date at the 95% confidence level ($\alpha = 0.05$).

The results of the soil sample analyses conducted on July 20, 1976 are presented in Table B-2. The analysis of soil plots A and B closely followed the procedure set for the bioassays. Tests were conducted for each variable between plots A and B. The null hypothesis $H_o: \mu_A = \mu_B$ was tested and accepted at the 95% level of confidence ($\alpha = 0.05$).

DAT	ТЕ (Ma X	PLOT A rl Strip) o ²	PI (Betwee X	.OT B en Strips) o ²	Cal. T DF	TABLE T. = 18	SIGNIFICANCE $\alpha = 0.05$
6-1	0	0	0	0	0	2.101	N.S.
7–1	1	0	0	0	0	2.101	N.S.
8-1	1 0.8	6 1.43	1.14	2.53	10.66	2.101	N.S.
9–1	L 0.6	0 0.67	1.05	0.89	1.61	2.101	N.S.
PARAMETER	PL (Marl X	OT A Strip) 0 ²	PLC (Betweer X	ут в 1 Strips) 0 ²	CAL. T. DF =	TABLE T. : 18	SIGNIFICANCE $\alpha = 0.05$
н _đ	7.21	0.0054	7.26	0.0027	1.750	2.101	N.S.
Ъ	18.8	13.5	21.27	20.17	1.639	2.101	N.S.
м	292.7	3807.0	226.0	1416.2	1.133	2.101	N.S.
CA	10487.0	774456.0	10069.0	241610.0	1.313	2.101	N.S.
MG	202.9	837.21	212.5	410.0	0.8596	2.101	N.S.

It should be noted that for soil pH at the 90% level of confidence, the null hypothesis could be rejected and the alternative hypothesis $H_i: \mu_a \neq \mu_b$ accepted. As the predetermined level of confidence was set at 95%, the null hypothesis is still accepted.

Between Field Analysis:

The between field damage sampling analysis was more complex than the within field study due to the field distribution of onion maggot populations. Onion maggot damage appears in a clumped or aggregated pattern within and between fields. There are several reasons for this aggregated distribution of onion maggot damage: 1) the irregularity of chemical insecticide application at planting (missing of spots within the application area), 2) the variability of abiotic factors enhancing survival (soil moisture levels, etc.), 3) the ovipositional attraction of gravid females to previously infested and/or rotting onions, and 4) the higher survival rates of larvae attacking previously damaged onions. This clumping or aggregation causes problems in the application of parametric statistics such as Analysis of Variance.

The sampling data fit a negative binomial distributions with no common K (see pages 24 to 42). By using the transformation log (x + 1), many negative binomial distributions can be normalized and the assumption of the analysis of variance met. Due to the high aggregation of the onion maggot population under these field conditions and the low population densities found in many of the sampled fields, these data could not be normalized, which rules out the use of parametric statistics.

Several non-parametric statistical tests are available for analysis of such data. The Kruskal-Wallis one-way ANOVA was chosen (Siegel 1956, and Nje et al. 1975). The analysis examined damage levels and soil types within each year and in the two years pooled. Table B-3 summarizes the data of that analysis. Although some other differences are noted throughout the analysis, the one soil type that is significantly different ($\alpha = 0.05$) throughout every test is soil type E. This soil type was found having significantly lower damage levels (see Table B-4) than the other soil types examined. Soil type CM was found low in damage during 1976, but had higher damage estimates in 1977 and its mean rank was readjusted.

Conclusion

The paired bioassay analyses of the marly tile area versus the area between tile lines indicated no damage difference between the plots throughout the growing season. Moderate damage levels were noted in many areas of the field and visual observations of those damaged areas showed no noticeable preference for marly areas.

The soil analysis performed indicated there was little difference between the plots in the parameters that were measured. Many of the other unmeasured micronutrients may actually be more important in the breakdown of a soil insecticide. If the bioassays would have indicated a significant difference, more intense soil analyses and chemical testing would have been pertinent.

The between field analyses seem to indicate an effect opposite that which was expected from the hypothesis in question. The soil

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TABLE

				ME	AN RANKS			
YEAR	ANALYSIS	z	MF-CM	CM -	I I 田 I	- WH -	x ²	SIGNIFICANCE
1976	One-way Anova	1150	655.3	544.8	5.318	638.5	61.7	0.01
	Multiple Range Test	1150	MF-CM	WH	CM	ы	$\alpha = 0.05$	
1977	One-way Anova	750	348.75	415.87	324.9	349.9	23.98	0.01
	Multiple Range Test	750	CM	WH	MF-CM	ш		
1976-77 Boolog	One-way Anova	1850	893.5	955.4	834.4	982.4	46.47	0.01
nationa	Multiple Range Test	1850	нм-см	MF-CM	ы			

VEND	SOIL TYPES	AND ORDER OF	MEAN RANK	(1 = high)
	MF-CM	СМ	E	НМ
1976	1	3	4	2
1977	3	1	4	2
1976-77 Pooled	3	2	4	1

TABLE B-4.	Ordering of ranks (onion maggot damage) by soil type for
	the Kruskal-Wallis ANOVA of Table B-3.

type highest in marl content seemed to consistently show lower damage levels than any other soil type examined. Overall, this study seems to indicate that areas high in marl concentrations did not increase the insecticide decomposition rate to a level detectable by natural population difference. 1976 Grant Onion Maggot Survey Data

	(50-	l meter	sample	s/f	ield)	FN	= Fie	eld	Number	
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1	1	9	2	2	0		3	2	0	
1	1	6	2	2	0		3	2	0	
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1976 Grant Onion Maggot Survey Data (continued)

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1977 Grant Onion Maggot Survey Data CDDA77ONTONETELDDAMACE (9X-12-3X-11.3X.12)

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	4	3	0		4	3	0		4	3	0	
	4	3	0		4	3	Û		4	3	0	
	4	З,	0		4	3	0		4	3	0	
	4	3	0		4	3	0		4	3	0	
	4	3	0		4	3	Û		4	3	0	
	4	3	Û		4	3	0		4	3	0	
	4	3	Ũ		4	3	Û		4	3	0	
	4	3	0		4	3	0		4	3	0	
	4	3	0		4	3	0		4	3	0	
	4	3	О		4	3	0		4	3	0	
	4	3	0		4	3	0		9	3	0	
	4	3	Û		4	3	Ú		9	3	0	
	4	3	0		4	3	O		9	3	0	
	4	3	Û		4	3	0		9	3	0	
	4	3	0		4	3	0		9	3	0	
	4	3	0		4	3	0		9	3	0	
	4	3	0		4	3	0		9	3	0	
	4	3	0		4	3	0		9	3	0	
	4	3	0		4	3	0		9	3	0	
	4	3	0		4	3	0		9	3	Û	

_	_							
9	3	0	10	4	0	11	2	0
9	3	0	10	4	0	11	2	0
à	Ž	0	10	11	n N	11	2	Õ
ó	2	ñ	10		6	4.4	2	0
9	2	0	10		0	11	2	0
9	3	0	10	4	0	11	2	0
9	3	0	10	4	0	11	2	0
9	3	0	10	4	0	11	2	0
9	3	Û	10	4	0	11	2	0
ó	Ř	0 0	10	й	Õ	11	2	õ
ó	2	0	10		0	11	2	0
9	2	0		4	0		2	0
9	3	0	10	4	0	11	2	2
9	3	0	10	4	1	12	4	0
9	3	0	10	4	0	12	4	0
9	3	0	11	2	0	12	4	0
ģ	à	0	11	2	0	12	4	Ō
10	й	ñ	11	2	õ	12	h	õ
10	n n	0	11	2	1	10	1.	0
10	4	0	11	2	I	12	4	0
10	4	0	11	2	0	12	4	0
10	4	0	11	2	2	12	4	0
10	4	0	11	2	0	12	4	0
10	4	0	11	2	1	12	4	0
10	4	0	11	2	0	12	4	0
10	Ц	Ō	11	2	õ	12	й	ñ
10	л	õ	11	2	2	12	7	ů Č
10		0	11	2	2	10		0
10	4	U ,	11	2	0	12	4	0
10	4	U	11	2	0	12	4	0
10	4	C	11	2	O	12	4	0
10	4	0	11	2	0	12	4	0
10	4	0	11	2	7	12	4	0
10	4	Û	11	2	Û	12	4	0
10	4	0	11	2	0	12	4	0
10	ц	ñ	11	2	ñ	12	Ц	Ō
16		ň	11	2	õ	12		õ
10	- 4),	0	11	2	1	10		0
10	4	U C	11	2		12	4	0
10	4	0	11	2	0	12	4	0
10	4	0	11	2	0	12	4	0
10	4	0	11	2	Ŭ	14	1	0
10	4	0	11	2	0	14	1	Ŭ
10	4	U	11	2	0	14	1	0
10	4	0	11	2	1	14	1	1
10	4	0	11	2	0	14	1	0
10	И	õ	11	2	õ	11	1	0
10	- T	0	11	2	1	1/1	1	n N
10	4	0	11	2	,	14	1	0
10	4	U		2	U	14		0
10	4	0	11	2	0	14	1	0
10	4	0	11	2	0	14	1	0
10	4	0	11	2	0	14	1	0
10	4	0	11	2	0	14	1	1
10	4	Û	11	2	0	14	1	0
10	4	Ō	11	2	0	14	1	0
10	Ц	õ	11	2	õ	14	1	ō
10	т)	ň	11	2	1	111	1	ñ
10	-1	v	11	۲.	1	1 77		0

14	1	0	16	2	0	17	4	0
14	1	0	16	2	0	17	4	0
14	1	0	16	2	0	17	4 Ц	0
14	1	õ	16	2	õ	20	2	Ő
14	1	Ū	16	2	Õ	20	2	1
14	1	3	17	4	Ō	20	2	1
14	1	õ	17	4	Ō	20	2	2
16	2	Û	17	4	2	20	2	3
16	2	0	17	4	1	20	2	1
16	2	1	17	4	0	20	2	0
16	2	0	17	4	0	20	2	0
16	2	0	17	4	0	20	2	1
16	2	0	17	4	0	20	2	0
10	2	0	17	4	U C	20	2	0
10	2	0	17	4	0	20	2	0
10	2	1	17	-4)i	0	20	2	0
16	2	0	17	<u>н</u>	0 0	20	2	0
16	2	õ	17	4	õ	20	2	0
16	2	ŏ	17	4	õ	20	2	1
16	2	1	17	4	0	20	2	Ū
16	2	0	17	4	Ú	20	2	0
16	2	0	17	4	0	20	2	0
16	2	0	17	4	0	20	2	1
16	2	C	17	4	O	20	2	0
16	2	1	17	4	2	20	2	0
16	2	Ũ	17	4	2	20	2	0
15	2	0	17	4	Ú	20	2	Ŭ,
15	2	0	17	4	0	<u> 20</u>	2	1
16	2	1	17	4	1	20	2	0
16	2	0	17	-4)i	0	20	2	0
10	2	1	17	-4 Ji	0	20	2	2
16	2	1	17	<u>ц</u>	0	20	2	1
16	2	0 0	17	4	õ	20	2	8
16	2	1	17	4	Ō	20	2	- 14
16	2	Ũ	17	4	Ō	20	2	2
16	2	Ŭ	17	4	0	20	2	0
16	2	U	17	4	3	20	2	1
16	2	5	17	4	3	20	2	1
16	2	1	17	4	2	20	2	0
16	2	0	17	4	0	20	2	3
16	2	0	17	4	0	20	2	0
16	2	Ŭ	17	4	0	20	2	1
10	2	U	17	4	U	20	2	0
10	2	U C	17	4)i	0	20	2	0
10 16	2	0	17	- 1	0	20	2	- 0 Б
16	2	0 D	17	- ц	ñ	20	2	1
16	2	0	17	4	õ	20	2	O
		-	•		-		-	-

1977	Grant	Onion	Maggot	Survey Da	ta	(continued)			
	20	2	6	22	2	0	211	1	0
	20	2	0	22	2	0	24	1	0
	20	2	0	2)	2	0	24	1	0
	20	~	0	23	2	0	24		0
	22	2	0	23	2	U	24	1	0
	22	2	0	23	2	0	24	1	0
	22	2	0	23	2	Û	24	1	0
	22	2	0	23	2	0	24	1	0
	22	2	1	23	2	0	24	1	2
	22	2	1	23	2	0	24	1	1
	22	2	2	23	2	0	24	1	0
	22	2	3	23	2	0	24	1	0
	22	2	1	23	2	0	24	1	õ
	22	2	5	23	2	Õ	21	1	2
	22	ົ້	2	2)	2	0	24	4	2
	22	2	5	4.5 0.2	2	0	24	1	0
	22	2	1	23	2	U	24		0
	22	2		23	2	0	24	1	0
	22	2	1	23	2	0	24	1	0
	22	2	2	23	2	0	24	1	0
	22	2	0	23	2	Ú	24	1	1
	22	2	1	23	2	0	24	1	0
	22	2	1	23	2	1	24	1	0
	22	2	1	23	2	0	24	1	0
	22	2	1	23	2	0	24	1	0
	22	2	0	23	2	0	24	1	Ō
	22	2	Õ	23	2	0 0	24	1	Õ
	22	2	0 0	23	2	Õ	21	1	0 0
	22	2	0	23	2	0	27	1	0
	22	2	U C	20	2	0	24	1	0
	22	2	0	23	2	0	24		0
	22	2	0	23	2	0	24		U
	22	5	0	23	2	0	24	1	0
	22	2	0	23	2	0	24	1	0
	22	2	0	23	2	0	24	1	0
	22	2	0	23	2	1	24	1	0
	22	2	0	23	2	0	24	1	0
	22	2	0	23	2	0	24	1	0
	22	2	0	23	2	0	24	1	0
	22	2	1	23	2	0	24	1	0
	22	2	0	23	2	0	24	1	0
	22	2	0 0	23	2	0	24	1	0
	22	2	0	23	2	õ	21	1	õ
	22	2	1	23	2	0	21	1	0
	22	2	2	2)	2	1	27	1	0
	22	2	<i>с</i>	2)	2	I C	24	1	0
	22	2	0	23	2	0	24		0
	22	2	U	23	2	U	24		1
	22	2	0	23	2	U	24	1	U
	22	2	0	23	2	U	24	1	Ŭ
	22	2	0	23	2	0	24	1	0
	22	2	0	23	2	0	24	1	0
	22	2	0	23	2	0	24	1	0
	22	2	0	23	2	0	25	1	0
	22	2	0	23	2	0	25	1	0
	22	2	0	24	1	O	25	1	0
							-		

1977	Grant	Onion	Maggot	Survey	Data	(continued)	1		
	25	1	0	26	2	0	27	2	0
	25	1	0	26	2	1	27	2	1
	25	1	Û	26	2	0	27	2	2
	25	1	Ú	26	2	0	27	2	0
	25	1	0	26	2	0	27	2	2
	25	1	0	26	2	5	27	2	U
	25	1	0	26	2	5	27	2	0
	25	1	0	26	2	0	27	2	2
	25	1	0	26	2	0	27	2	0
	25	1	0	26	2	0	27	2	1
	25	1	1	26	2	0	27	2	3
	25	1	1	26	2	0	27	2	Ō
	25	1	0	26	2	0	27	2	2
	25	1	0	26	2	1	27	2	0
	25	1	0	26	2	0	27	2	1
	25	1	Ũ	26	2	3	27	2	1
	25	1	0	26	2	õ	27	2	0
	25	1	0	26	2	Ü	27	2	0
	25	1	Ō	26	2	0	27	2	Ū
	25	1	0	26	2	0	27	2	0
	25	1	0	26	2	0	27	2	0
	25	1	Ú	25	2	0	27	2	0
	25	1	0	26	2	3	27	2	0
	25	1	Û	26	2	Õ	27	2	0
	25	1	0	26	2	0	27	2	0
	25	1	0	26	2	0	27	2	Ŭ
	25	1	Ō	26	2	Ō	27	2	0
	25	1	0	25	2	0	27	2	0
	25	1	Û	26	2	0	27	2	3
	25	1	Û	26	2	0	27	2	Ū
	25	1	Û	26	2	0	27	2	3
	25	1	0	26	2	2	27	2	Ũ
	25	1	Ū.	26	ž	1	27	2	1
	25	1	0	26	Ž	Ó	27	2	0
	25	1	Ō	26	2	2	27	$\overline{2}$	0
	25	1	0	26	2	3	27	2	Ō
	25	1	0	26	2	Ó	27	2	0
	25	1	õ	26	2	2	27	2	0
	25	1	0	26	2	3	27	2	0
	25	1	õ	26	2	ŏ	27	ē	0
	25	1	0	26	2	3	27	2	0
	25	1	õ	26	ē	õ	27	2	0
	25	1	0	26	2	6	27	2	Ō
	25	1	õ	26	ī	Ō	28	3	0
	25	1	0	26	2	Ō	28	Ĩ	0
	25	1	Ō	27	2	0	28	3	Ő
	25	1	0	27	$\overline{2}$	3	28	ž	Ō
	26	2	1	27	$\overline{2}$	ō	28	3	Ō
	26	$\overline{2}$	1	27	2	0	28	3	0
	26	2	0	27	2	0	28	3	0
	26	2	Ū	27	2	2	28	ž	0
	26	2	0	27	2	1	28	3	0

/	Grant	Union	Maggot	Survey	Data	(CONTI	nuea)			
	28	3	0	29	3	0		29	3	0
	28	3	0	29	3	0		29	3	0
	28	3	0	29	3	0		29	3	0
	28	3	Û	29	3	Ū		29	3	Û
	28	3	0	29	j	0		20	3	0
	28	Ĩ	0	29	1 3	0		29	3	0
	23	ĩ	0	29	1 3	Ō		29	ž	Ō
	28	Ŕ	0	20	, <u>,</u>	Õ		29	ĩ	Ő
	28	2	õ	20	2	õ		20	2	õ
	29	2	0	20	2	0		20	2	0
	20	2	3	20	2	0		29	ר כ	0
	20	2	2	29	,) ,	0		29))	0
	20	2	0	29	5	0		29	3	0
	27	5	0	29	5	0		29	3	0
	28	3	3	29	5	0		29	3	0
	28	3	0	29	3	0		29	3	0
	23	3	0	29	3	Ú		29	3	0
	29	3	0	29	3	0		29	3	0
	29	3	0	29	3	0		29	3	0
	29	3	0	29	3	Û		29	3	0
	29	3	Ü	29	3	0		29	3	0
	29	à	0	29		0		29	3	0
	20	2	Ū.	20	, ,	Ō		29	ĩ	Õ
	-)	<u> </u>	3	-)	, J	~		- /	2	5

APPENDIX C

Regional Plant Damage Sample Data

(REP = Replicate, DIS = Distance, OBS = Observation)

Bravo 5/26/77 - 6/2/77

Grant 6/2/77 - 6/7/77

			CI	DDAOMS	URVEY	GRANTT1 (12,13,	12)
1	0	0	2	0	0	8	54	5
2	0	0	3	3	3	9	Ũ	0
3	0	0	3	4	4	10	0	0
4	0	0	3	5	4	1	0	0
5	0	0	3	6	3	2	0	0
5	0	0	4	66	6	3	0	0
7	0	0	4	67	6	4	0	0
8	0	0	4	63	6	5	33	2
9	υ	υ	24 -	69	6	6	0	0
10	0	0	5	Ü	υ	7	Ü	Û
1	C	0	6	08	२	8	0	0
2	0	0	7	69	4	9	87	1
3	0	0	7	72	3	10	0	0
4	9	1	8	0	0	1	0	0
5	52	4	9	90	1	2	45	2
6	0	0	9	94	4	3	42	4
7	0	0	10	0	0	4	Û	0
8	0	0	1	0	0	5	0	0
9	60	1	2	33	1	6	Ú	0
10	0	0	3	0	0	7	υ	0
1	2	2	4	0	0	8	0	0
1	12	2	5	42	1	9	0	0
1	30	3	5	0	0	10	0	0
1	87	7	7	0	0			

Lapeer 5/31/77 - 6/15/77

				CDDA	OMSUR	VEYLAPT1	(12,13	, I2)
1	0	0	2	0	0	1	80	1
2	Õ	õ	3	Õ	õ	1	87	2
2	Õ	õ	ц	Õ	õ	2	Ő	0
ر نا	õ	0	, 5	Õ	Ő	2	12	1
5	õ	0 0	5	Ő	0	د د	12	1
5	ő	0	7	0	0	2	22	1
7	0	0	1	0	0) 2	2)	1
1	0	0	0	0	0	3	51	1
8	0	0	9	0	0	3	47	1
9	0	0	10	0	0	3	58	2
10	0	0	1	0	0	3	69	1
1	Û	0	2	0	0	3	77	1
2	0	0	3	0	0	3	82	1
3	0	0	Ĵ ₄	0	0	3	87	1
1,	0	0	5	0	0	3	94	2
5	0	0	6	0	0	3	93	2
6	0	Ō	7	0	0	Ĩ,	0	0
7	Ō	Ō	8	Õ	Ō	5	Ō	0
Ŕ	ñ	õ	ğ	Ō	Ō	6	ŭ	1
Q	Õ	õ	10	n N	õ	6	7	1
10	ů N	õ	1	16	1	6	26	1
10	0	0	4	71	4	0 4	20 60	
I	0	0	1	()	I	D	60	2

7 8 0	000	0	4 5 5	54 52	1	9 10	100 1	1
9 10 10	13 64	1	5 5 6	95 100 36	2	10 10 10	30 37 38	2
10 10	77 86	2 1	6 7	96 20	1 1	10 10	40 62	1
1 2	4 Օ	3 0	7 7	28 32	1 2	10 1	80 22	1 3
3 4	0 100	0 1	7 7	46 38	1 4	1 2	63 0	1 0
56	0 0	0	8 9 9	22	32	3 3	22 74	1
7 7 0	80 100	2	8 8	24 28 20	1 2	4 5	0 46 5 1	02
2 9 0	40	1	5 8 8	30 34 36	1	5	54 84	1
9 9	39 39	1	8 8	50 46 50	- 2 7	7 8	64 49	2 7
9 9	40 60	2	88	53 60	32	8	49 53	1
9 9	61 67	2 3	8 8	64 72	3 1	9 9	83 92	1 2
9 9	71 75	1 4	8 8	78 88	2 1	10 1	0 0	0 0
9 9	81 90	1 3	8	90 82	1	2	24 0	1 0
9	91 92 03	2 1 2	8 9 0	99 1	1	4 5 6	0	0
9 10 10	95 15 24	2 1 4	9 9	8 12	1	7 8	0	0
10 10 10	25 25	2	9 9	24 26	1 1	9 10	0 0	0 0
10 10	54 60	1 2	9 9	32 34	4 2	1 1	53 60	1 1
10 1	74 4	1 7	9 9	36 38	1 2	1 2	70 Ŭ	2 0
1	36 66	5	9 9	42 46	1	3 4 5	10 0	1
1	68 69	۲ 1 1	9	52 56	1	5 6 7	0	0
1	70 71	1	9 9 9	61 63	4 3	8 9	0	0
1	94 100	, 1 1	9 9	65 69	3	10 10	35 39	2
2 2	42 99	1 1	9 9	74 76	2 1	10 10	69 84	1
3 4	0 48	0 2	9 9	84 90	2 2	10	100	1

					CDDAOMSUR	ÆYTRIT]	(12	,13,12)
123456789011234567890123456789012345678901233456789012345	002000000870000000000000000000000000000	002000022000000000000000000000000000000	789012345678901223456789012345678901223456789012234567890122		CDDAOMSURV 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	/EYTRITJ 4 5 6 7 9 10 12 3 4 5 6 7 9 10 10 10 10 10 10 10 10 10 10 10 10 10	(12 000000000000000000000000000000000000	,I3,I2) 0 0 0 0 0 0 0 0 0 0 0 0 0
6	0	0	3	0	0	10	87	3

Tricounties 6/6/77 - 6/10/77

Bravo 7/7/77

			CDDAC	MSURVE	(12,1	(12,13,12)		
1	12	4	7	40	7	6	0	0
1	13	4	8	62	2	7	0	0
1	14	4	8	63	2	8	Ũ	Û
1	15	4	9	10	2	9	0	0
1	42	5	10	0	0	10	0	0
1	43	5	1	0	0	1	0	0
2	84	4	2	0	0	2	0	0
2	85	4	3	0	0	3	0	0
2	89	5	4	0	0	Ĩ,	0	0
2	9 0	5	5	0	0	5	40	5
2	91	5	6	0	0	5	41	5
2	92	5	7	0	0	6	0	Ō
3	0	0	8	0	0	7	0	0
4	0	0	9	0	0	8	0	0
5	2	6	10	0	0	9	υ	0
5	3	7	1	0	0	10	0	0
5	18	10	2	0	0	10	55	5
5	19	10	3	0	0	10	90	8
5	28	3	4	0	0			
6	0	0	5	0	0			

Grant 7/14/77 - 7/20/77

				CDDAC	MSURV	EYGRANTT2	(12,1	3,12)
1	U	0	1	0	0	6	0	0
2	52	2	2	0	0	7	0	0
3	28	2	3	0	0	8	0	0
4	0	0	4	0	0	9	0	0
5	6	1	5	0	0	10	0	0
5	72	3	6	0	υ	1	U	Ú
5	74	6	?	0	O	2	О	0
5	94	1	8	0	0	3	0	0
6	0	0	9	0	0	4	Ŭ	0
7	40	2	10	0	0	5	0	0
7	45	1	1	0	0	6	0	0
8	0	Ũ	2	0	0	7	0	0
9	0	Ū	3	0	0	8	0	0
10	Û	0	24	0	0	9	0	0
1	Û	0	5	0	0	10	Ü	0
2	75	4	6	0	0	1	0	0
2	34	2	7	0	0	2	0	0
3	0	0	8	0	0	3	0	0
4	0	0	9	0	0	4	0	0
5	0	0	10	0	0	5	0	0
6	0	0	1	0	0	6	0	0
7	0	0	2	0	0	7	0	0
8	0	0	3	0	0	8	υ	Ù
9	100	1	4	0	0	9	U	0
10	0	0	5	0	0	10	0	0

Lapeer	7/1	3/77 -	7/22/7	77 CDI	DAOMSU	RVEYLAPT2	(12,	13,12)
1	0	0	9	0	0	4	84	3
2	0	0	10	0	0	Ц,	90	1
3	0	0	1	2	2	5	1	2
4	0	0	1	4	4	5	4	5
5	0	0	1	22	2	5	10	2
07	0	0	1	24	3	5	12	4
l Q	0	0	1	20	2 2	5	10	1
q	0 0	0	1	36	2	5	80	1
10	õ	0 0	1	56	2	5	92	6
1	υ	U	1	60	1	6	2	3
2	0	0	1	66	4	6	5	2
3	0	0	1	67	5	6	26	2
4	0	0	1	72	1	6	44	2
5	0	0	1	74	1	6	43	1
り 7	0	0	1	/8 06	1	0	70	2
Q	0	0	1	90	5	6	73	6
ġ	õ	0	1	100	5	6	80	2
10	Ũ	Õ	2	1	1	ő	82 82	2
1	Ō	Ō	2	2	1	6	90	$\overline{2}$
5	0	Ŭ	2	6	3	7	54	2
3	0	0	2	7	1	7	30	1
4	0	0	2	10	1	8	1	1
5	0	0	2	14	1	8	4	2
0 7	0	0	20	19	1	C Q	12	1
Ŕ	0	0	2	20	1	5 8	19	1
g	õ	Õ	2	21	1	8	20	1
10	Ō	Ō	2	40	5	8	32	2
1	0	0	2	42	2	8	34	1
2	0	0	2	43	1	8	52	1
3	0	0	2	46	1	8	64	6
4	0	0	2	50	1	8	65	1
5	0	0	2	50	3	2	0/ 8/1	1
7	0	0	2	- 55 - 60	2 1	5 8	24	1
Ŕ	υ υ	Û	2	00 72	1	Ř	99	4
ğ	Õ	Õ	Ē	80	1	8	100	1
10	0	0	3	10	2	9	21	1
1	0	0	3	30	2	9	24	1
2	0	0	3	62	2	9	30	3
3	0	0	3	82	2	9	34	1
4	0	U C	3	94	4	9	30	3
5 6	0	0	4	<u>ک</u>	2	У 0	40 なつ	ے 1
7	0	0	4 Ц	20	2	9	72 50	1
8	õ	0	4	74	1	9	68	1
-	-					-		

9	70	3	5	0	0	•	70	0
9	78	3	6	0	0	ş	30	0
9	80	2	7	32	3	Q	90	0
9	- 88	4	7	80	4	10	0 C	0
9	98	6	8	26	2		1 73	1
9	100	1	8	74	1		2 0	0
10	14	1	9	0	0		3 1	1
10	16	2	10	49	2		3 2	1
10	60	3	1	0	0		3 80	1
10	64	1	2	0	0		3 94	1
10	65	1	3	0	0	1	+ U	Ú
10	68	2	4	0	0	5	5 90	1
10	7Ŭ	2	4	20	1	6) 0	0
10	74	2	4	56	1	-	7 10	1
10	80	1	5	0	0	-	7 15	1
10	81	2	6	21	5		7 20	1
10	83	3	7	0	0		7 92	1
10	9 0	20	8	0	0	3	3 5	1
10	100	1	9	Û	0	8	3 24	1
1	54	3	9	80	2	8	3 34	1
2	0	0	10	30	5	8	36	1
3	0	0	10	100	1	8	3 37	2
4	1	1	1	48	1	ş	3 44	1
4	24	1	2	100	1	8	3 45	1
4	30	1	3	0	0	8	3 46	3
4	32	1	4	0	0	ç) 66	1
4	38	1	5	0	0	ç	9 67	4
4	48	3	6	0	0	10	0 (0

Tricounties 7/6/77 - 7/20/77

CDDAOMSURVEYTRIT2 (12,13,12)

1	3	1	7	0	0	3	0	0
2	0	0	8	0	0	4	0	0
3	0	0	9	0	0	5	0	0
4	0	0	10	0	0	6	0	0
5	0	0	1	0	0	7	0	0
6	0	0	2	0	0	8	υ	Û
7	0	0	3	0	0	9	υ	0
8	0	0	4	0	0	10	0	0
9	0	0	5	0	0	1	0	0
10	0	0	6	0	0	2	0	0
1	0	0	7	0	0	3	0	0
2	0	0	8	0	0	4	0	0
3	0	0	9	0	0	5	0	0
4	0	0	10	0	0	6	0	0
5	0	υ	1	0	0	7	0	0
6	0	0	2	0	Ŭ	8	0	υ

9	0	0	3	0	0	7	0	0
10	0	0	4	0	0	8	0	0
1	Ŭ	Û	5	0	0	· 9	0	0
2	0	0	5	0	0	10	0	0
3	0	0	7	0	0	1	0	0
4	0	0	8	0	0	2	0	0
5	0	0	9	0	0	3	0	0
07	0	0	10	0	0	4	0	0
(0	0		0	0	5	0	0
2	0	0	2	0	0	07	0	0
9 10	0	0	5	0	0	1	0	0
10	0	0	-17 5	0	0	0	0	0
2	0	0	5	0	0	9 10	0	0
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5	õ	Õ	ğ	õ	õ	2	õ	õ
6	Õ	õ	10	õ	õ	ŭ	õ	õ
7	0	0	1	Ō	0	5	Ŭ	0
8	0	0	2	0	0	6	0	0
9	0	0	3	0	0	7	υ	0
10	0	0	4	0	0	8	0	0
1	0	0	5	0	0	9	0	0
2	0	0	6	0	0	10	0	0
3	0	0	?	0	0	1	0	0
4	0	0	8	0	0	2	0	0
5	0	0	9	0	0	3	0	0
5	0	0	10	0	0	4	0	0
/	0	0	1	0	0	5	0	0
3	0	0	2	0	0	0	0	0
9 10	0	0	5	0	0	1	0	0
10	0	0	4 5	0	0	0 0	0	0
2	0	0	5	0	0	9 10	0	0
۲.	U	U	0	U	U		0	U

Region	nal Plant	Dama	ge Samp	le Dat	:a (cont	inued)			
	Bravo	5/13	/77 -	5/14/	77					
					(CDDA	OMSURVE	YBRAVOTO	(12,1	3,12)
	1 1 1 1 1 1 2 2	4 13 24 27 43 44 71 79 83 7 93	1 2 1 1 1 1 2 1 1		3	0 13 27 34 62 83 53 0 32 42	0 1 17 2 1 1 1 0 0 1	9 10 1 2 3 4 5 6 7 9 10	46 0 0 0 0 0 0 0 0 0 0 0	3 0 0 0 0 0 0 0 0 0
	Grant	5/17	/77			CDDA	OMSURVE	EYGRANTTO	(12,1	3,12)
	1 1 2 3 4 4 4	8 93 0 13 51 77 84	1 0 1 2 1 1		+ + 5 5 5 5 5	87 90 91 54 71 78 94 0	1 1 2 12 1 1 0	7 9 10 10 10 10	0 21 0 31 37 40	0 1 0 6 1 1
	Lapeer	5/1	7/77			CDDA	.OMSURVI	EYLAPTO (12,13,	12)
	1 3 4 5 6 7 8 9 10 1 1 1 1	0 0 0 0 0 0 0 0 0 15 71 80 87	0 0 0 0 0 0 0 0 0 0 0 1 1 1 2		2 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3	0 12 19 28 31 47 58 77 87 87 98 98 0	0 1 1 1 2 1 1 1 2 0	5 6 6 7 8 9 10 10 10	0 4 7 26 50 0 0 13 64 77 86	0 1 1 2 0 0 0 1 1 2 1
	Tricour	nties	5/20)/77		CDDA	OMSURVI	EYTRITO (12,13,	12)
	1 2 3 4	0 0 0 57	0 0 0 1		5 5 7 8	0 0 0 0	0 0 0	9 10	0 0	0 0

APPENDIX D

Mass Rearing Technique

Mass rearing programs have been carried out by several researchers (Perron et al. 1951, Rawlins 1953, Friend and Patton 1956, Workman 1948, Elmosa 1960, and Niemczyk 1964) using somewhat different techniques. Several of these methods have been explored at Michigan State University and a modification of the method presented by Niemczyk (1964) was found as the most desirable.

Niemczyk's rearing technique was developed for implementation at the Agriculture Canada Entomology Laboratory, London, Ontario. Recent modifications to Niemczyk's technique have been made to increase production levels and efficiency levels at the London laboratory. These modifications have resulted in increasing the rearing capacity of the London facility to 2,000,000 flies per month (Harris 1976, personal communication) and have produced similar results at Michigan State University.

Modifications to Niemczyk's Rearing Technique:

Adults (1000-2000 per 30 cm³ cage) were held at $\pm 26^{\circ}$ C and 16 h photoperiod and provided with honey, a mixture of yeast, yeast hydrolysate, soya bean meal and water. The flies were transferred to clean cages weekly. For oviposition 15 cm plastic petri dishes were filled with 1:1 muck/sand kept moist via a dental wick extending beneath the

container to a water reservoir. Two sliced onion halves (ovipositional attractants) were placed on top of the soil. Eggs were collected twice weekly. Larvae were reared in plastic dishpans 30 x 22 x 15 cm deep containing several 5 mm holes in the bottom for drainage of excess moisture. The pan was filled with onion sleeves arranged on a 3 cm layer of dry sand. Eggs, mixed in 1:1 sand/muck, were deposited around the sliced onions. A layer of plastic film was placed over the sliced onions to maintain a moisture level. Additional food was added 10 days later by removing the container contents, adding dry sand and sliced onions and replacing the original contents on top. When the original food supply was exhausted, larvae moved readily to the new onions below. The resultant pupae were removed and placed in containers for emergence. Larvae and pupae were reared at $\pm 22^{\circ}C$ and 16 h photoperiod with the two procedures requiring approximately 20 and 12 days respectively.

APPENDIX E CDDAALLONIONCLUMP (1x,13,12,7(2x,13),2F10.3) Age Specific Data (see II,B) NOTE: Parameter Y is double its true value in days 188-244. (C = clump, G = grade, E = eggs, 1, 2, +3 = 1-3 instars, P=pupae, X and Y coordinates)

DAY	С	G	E	1	2	3	Р	X	Y
174	1	1	0	0	C	0	0	.040	025
174	1	1	0	0	ງ	0	0	.095	100
174	1	1	0	0)	0	0	. 141	002
174	1	1	0	0	2	0	0	.217	.022
174	1	3	0	0)	2	0	.293	.020
174	1	3	1	4	5	0	0	• 368	.059
174	T	3	0	0	0	0	1	.444	.093
174	1	1	0	0	0	0	0	• 5 3 5	033
171	1	5	0	0))	1	0	.001	.041
174	1	2	0	2	2	1	0	. / U I	.039
171	1	2	2	5	7	2	0	101	.030
174	1	1	.) 0	0	0	0	0	• 000	- 020
174	1	1	0	0	2	õ	0	1 040	- 040
174	1	י ג	ő	õ	ĵ	1	0	1, 120	008
174	1	3	õ	õ	2	1	õ	1.206	.007
174	1	Ř	õ	Õ	- C	6	õ	1.302	044
174	1	í	Ō	Ő	Ŋ	Ō	õ	1.403	021
174	1	1	0	0	2	0	0	1.488	047
174	1	1	0	0	C	О	0	1.559	.002
174	1	1	0	0	C	0	0	1.615	.001
174	1	1	0	0	ິ	0	0	1.655	.000
174	1	1	0	0	う	0	0	.041	.417
174	1	1	0	0	с С	0	0	.137	.519
174	1	2	6	0	0	1	0	.208	.468
174	1	2	0	8	4	0	0	.298	.442
174	1	3	0	0	3	1	0	• 384	. 490
174	1	3	0	0	Ĵ,	2	0	. 475	. 414
174	1	3	0	0	5	0	0	.536	. 463
174	1	1	0	0)	0	0	.611	.437
174	1	1	0	0)	0	0	.722	- 485 150
171	1	1	0	0	5	0	0	.508	.459
171	1	1	0	0	0	0	0	• 0 (9	000. 100
171	1	1	4	0	0 0	0	0	• 004	• 334
171	1	1	0	n n	0	0	0	• 92 9 070	• 252 257
174	1	2	ó	Ц	, n	2	Ő	• 97 9 1 045	• .5.57 ДОК
174	1	2	й	ō	ñ	1	1	1, 116	504
174	1	ĩ	0	ŏ	Ó	ò	o O	1.207	. 478
174	1	ĩ	Õ	ŏ	Ĵ	ŏ	õ	1.277	452
174	1	1	Ō	Ō	Ĵ	Ō	Õ	1.338	.526
174	1	2	3	Ō	Ô	Ō	Ō	1.418	.400
174	1	1	ō	0	າ	0	0	1.489	.375
174	1	1	0	0	С	0	0	1.550	. 423
174	1	1	0	0	C	0	0	1.615	• 37 3
174	1	1	0	0	0	0	0	1.651	• 397
174	1	0	0	0	С	0	0	0.000	0.000

Age	Spe	cific	Data	(cont	inued)				
	174	2	1	0	0	Û	0	Û	.045	024
	174	2	1	0	0	0	Û	Û	. 105	231
	174	2	1	Û	Ó	Û	0	0	. 156	046
	174	2	2	Û	0	4	0	1	.216	122
	174	2	2	0	0	Ú	3	0	.296	 172
	174	2	2	6	0	6	Û	1	• 386	 142
	174	2	1	Û	0	0	Ú	0	• 452	192
	174	2	3	0	0	0	0	0	•537	084
	174	2	3	0	0	0	4	Û	• 698	026
	174	2	3	0	0	0	2	0	•788	101
	171	2	2	0	0	0	2	0	1.130	055
	17 <u>1</u>	2	1	0	0	0	0	0	1 310	- 109
	174	2	י ג	ů ů	õ	0	6	ő	1 306	- 052
	174	2	ר א	õ	õ	0 0	0	1	1 <u>Ц</u> Я1	- 010
	174	Ž	1	0 0	ŭ	õ	0 0	Ġ	1.878	165
	174	2	1	Ũ	õ	õ	õ	õ	1,963	083
	174	2	1	0	0	Ō	Ō	Ō	2.058	210
	174	2	1	0	0	0	0	Ó	2.129	129
	174	2	1	0	0	0	Û	0	2.209	126
	174	2	1	0	0	0	0	Ó	2.254	200
	174	2	1	0	0	0	0	0	2.305	 123
	174	2	1	0	0	Û	0	0	2.380	 120
	174	2	1	0	Û	0	0	0	2.480	090
	174	2	1	0	0	0	0	0	2.551	192
	174	2	3	0	0	12	0	0	2.545	110
	174	2	3	0	0	4	0	0	2.721	133 130
	1/4 17)1	2	3	2	0	0	0	2	2.002	- 130
	17 <u>1</u>	2	2	0	0	0	3	0	2 072	- 200
	174	2	2	ő	ŏ	0 0	0	0 0	3.063	199
	174	2	2	ŏ	Å Å	ŏ	Ž	ŏ	3, 143	092
	174	2	3	Ō	õ	Ō	2	Ō	3.229	.042
	174	2	3	0	0	0	Ó	1	3.309	.019
	174	2	3	0	0	0	0	0	3.379	109
	174	2	1	Û	0	Û	0	Ó	3.460	106
	174	2	1	0	0	0	0	Ó	.041	.419
	174	2	1	0	0	0	0	0	. 131	• 396
	174	2	1	0	0	0	0	0	. 197	• 399
	174	2	1	0	0	0	0	0	• 257	.421
	174	2	1	0	0	0	0	0	• 322	• 40 3 22 9
	1(4 17)	2	5	0	0	0	0	0	• 292 1183	• ⊃⊂ • 1188
	17)	2	3	0	0	3	1	0	• • • 5 543	. 4 65 ДАЦ
	т 17Ц	2	2	à	õ	2	1	õ	• 9 50	. 401
	174	2	1	0	õ	õ	ò	õ	1.126	407
	174	2	1	3	Ō	Ō	Ō	Ō	1.211	.410
	174	2	3	ŏ	Ō	Ō	Ō	Ō	1.301	. 362
	174	2	3	Ō	Û	0	0	0	1.617	.321
	174	2	3	0	0	Û	0	2	1.708	.377
	174	2	3	0	0	0	0	0	1.803	• 354
	174	2	1	Û	Ú	Û	Ú	Ú	1.869	• 383
174	2	1	Ŋ	0	0	0	Û	1.909	.500	
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174	2	1	Û	0	0	0	O	1.974	.439	
174	2	1	0	0	0	0	O	2.039	.415	
174	2	1	Û	0	Û	Û	0	2.095	• 339	
174	2	1	0	0	Û	0	Û	2.210	.317	
174	2	1	Û	0	0	0	Û	2.246	. 490	
174	2	1	Û	O	0	0	Û	2.290	.294	
174	2	1	Û	Ú	0	0	0	2.376	.271	
174	2	1	0	0	0	0	Û	2.441	.221	
174	2	1	0	0	0	0	U	2.496	. 197	
174	2	3	0	0	0	2	Û	2.571	.252	
174	2	3	Û	Û	Ó	0	Û	2.657	• 334	
174	2	3	Û	0	6	3	0	2.722	.284	
174	2	3	G	Û	3	Û	0	2.808	• 366	
174	2	2	6	0	Û	1	Û	2.878	.342	
174	2	2	Ú	U	0	1	Û	2.973	• 346	
174	2	1	Û	0	Û	Û	Û	3.054	• 375	
174	2	1	0	0	0	0	0	3.119	• 377	
174	2	1	Û	0	0	0	0	3.209	.407	
174	2	1	0	Û	Û	Û	0	3.280	• 357	
174	2	1	0	0	0	0	0	3.370	.308	
174	2	1	Û	0	0	0	Û	3.460	• 338	
174	2	Û	Û	Û	Û	Û	U	0.000	0.000	
174	3	1	C	C	Û	0	Û	.030	051	
174	3	1	Û	Ú	Û	Ú	Ú	.090	. 124	
174	3	1	Û	Û	0	0	0	. 145	102	
174	3	1	Ú	Û	0	Û	Ú	.215	.021	
174	3	1	0	0	Û	Ú	Û	.270	080	
174	3	1	Û	0	Ú	Û	Ú	.280	.220	
174	3	1	O	0	Û	0	Û	. 325	.045	
174	3	1	Ú	0	0	Û	0	• 375	.019	
174	3	2	Û	0	6	0	U	. 430	•068	
174	3	1	0	0	Ú	0	0	. 490	.117	
174	3	1	Û	0	0	0	Û	•555	.091	
174	3	2	0	0	0	2	0	.700	.038	
174	3	1	O	0	0	0	0	.780	.062	
174	3	2	0	0	0	0	0	.865	.036	
174	3	1	0	0	0	Û	Ú	.950	.034	
174	3	1	Ó	0	0	0	Û	1.040	.009	
174	3	1	Ó	0	Ó	0	0	1.085	.082	
174	3	1	0	0	0	0	0	1.095	280	
174	3	1	Û	0	Ó	Û	O	1.145	.006	
174	3	3	Ó	Û	0	O	2	1.210	.030	
174	3	1	Ó	O	0	O	Û	1.305	.053	
174	3	1	0	0	0	0	0	1.375	048	
174	3	1	0	0	0	0	Û	1.400	210	
174	3	1	0	0	0	0	Û	1.420	. 101	
174	3	1	0	0	0	0	0	1.470	150	
174	3	1	0	0	Û	0	0	1.530	.050	
174	3	1	0	Û	Û	Û	0	1.560	201	
174	3	1	Ú	0	Û	0	Ú	1.605	.048	
174	3	1	Ó	Ú	Ú	Û	Ú	1.640	 152	

174 174	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	1 1 1 1 3 3 1 1 1 1 1 1 1 1 1 1 1 1 1 1	000000000000000000000000000000000000000	000000000000000000000000000000000000000	000000000000000000000000000000000000000	000000000000000000000000000000000000000	000000000000000000000000000000000000000	$\begin{array}{c} 1.700\\ 1.710\\ 1.771\\ 1.755\\ 1.830\\ 1.925\\ 1.926\\ 1.980\\ 1.980\\ 2.045\\ 2.045\\ 2.045\\ 2.045\\ 2.045\\ 2.045\\ 2.045\\ 2.045\\ 2.045\\ 2.045\\ 2.045\\ 2.045\\ 2.045\\ 2.045\\ 2.045\\ 2.045\\ 2.060\\ 2.280\\ 2.350\\ 2.380\\ 2.350\\ 2.380\\ 2.350\\ 2.945\\ 2.965\\ .049\\ .144\\ .214\\ .264\\ .324\\ .389\\ .454\\ .529\\ .579\\ .639\\ .709\\ .764\\ .874\\ .959\\ 1.029\\ 1.089\\ 1.169\\ 1.234\\ 1.284\\ 1.369\\ 1.399\\ 1.434\end{array}$	$\begin{array}{c} .122 \\279 \\0064 \\010 \\010 \\010 \\010 \\010 \\010 \\010 \\010 \\010 \\010 \\000 \\$
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e spec	TITC	Dala	(Cont	Inded	J				
174	3	3	0	0	Ó	0	0	1,489	. 500
174	จั	จั	õ	Õ	Ō	Õ	õ	1 540	. <u>)</u>
174	2	2	Õ	õ	õ	Š	õ	1 600	•
17/1	2	2	ő	õ	õ	n n	2	1.009	. 44.5
171	י ר	<u>ר</u>	0 A	C C	0	0	2	1.009	.4/2
1 (4	3	3	0	0	0	0	0	1.724	.421
174	3	3	0	0	0	2	0	1.774	• 495
174	3	3	0	0	Ú	Ú	1	1.854	. 444
174	3	2	0	0	6	2	Û	1.939	• 443
174	3	2	0	0	0	3	0	2.019	.416
174	3	3	0	0	0	0	0	2.104	. 390
174	3	3	0	0	0	1	0	2,124	.580
174	3	3	0	0	0	1	0	2,159	464
174	ŝ	Ĩ	Û	0	0	0	0	2,209	. 590
174	Ř	Ŕ	Ō	Õ	Õ	Õ	õ	2,219	489
174	จั	1	õ	Õ	õ	õ	Õ	2 304	1 37
174	2	1	Ğ	õ	õ	ů	õ	2 37/1	.4)
17/1	2	2	õ	ů Č	Л	1	1	2.160	
171	נ ז	<u>ר</u>	0	0	4	0	1	2.409	• 459
1 4	י ר	<u>,</u>	0	0	0	0		2.544	.405
1 (4	3	3	0	0	0	0	0	2.504	.550
174	3	3	0	0	0	2	1	2.609	. 407
174	3	2	11	2	1	0	0	2.684	• 355
174	3	3	C	C	0	C	0	2.744	• 379
174	3	1	0	0	Ó	0	Ú	2.799	• 378
174	3	1	0	Û	0	0	0	2.944	•573
174	3	1	O	0	0	0	0	2.864	• 327
174	3	.1	0	0	C	0	Û	2.929	.351
174	3	1	0	0	0	0	0	2.969	.526
174	3	0	0	0	0	0	O	0.000	0.000
174	4	1	0	0	0	0	0	.040	001
174	4	1	Ō	Ó	Ō	Ō	Ō	. 135	- 052
174	4	1	ŏ	Ō	Ō	Ō	Õ	.210	054
174	ц	1	õ	Ō	õ	õ	ŭ	.254	- 055
174	Д	1	õ	õ	ő	õ	õ	300	- 056
17)	-т И	2	17	0	<u>0</u>	2	0	• JU 9 27 1	- (53
171		2		0	0	2	0	• 517	055
174	4	2	0	0	0	2	0	.404	011
1/4	4	1	2	0	0	1	0	• 77 9	014
1 (4	4	2	5	0	0	1	0	• 0 <u>3</u> 0	.009
174	4	2	0	0	0	4	0	• (13	042
174	4	1	0	0	0	0	0	•778	092
174	4	1	0	0	0	0	0	.828	069
174	4	2	0	0	0	2	0	• 893	071
174	4	3	O	0	5	0	1	•958	049
174	4	3	Û	Ú	0	2	1	1.242	.067
174	4	1	0	O	Û	0	0	1.312	056
174	4	1	0	0	0	0	0	1.367	107
174	4	1	0	0	Û	0	0	1.431	.063
174	4	1	0	0	0	0	0	1.466	107
174	4	1	Ō	Ō	Ō	Ō	Ō	1.536	.036
174	<u>4</u>	1	0	õ	Ō	Ō	õ	1.611	039
174	ц	1	ŏ	õ	õ	õ	õ	1_686	-,017
171	1	1	ñ	õ	õ	õ	õ	1.726	001
171	-+)i	1	0 A	ň	ň	ň	ň	1 761	_ 120
1/4	4	1	0	U	U	U	U	1. (01	130

174	4	1	0	0	0	O	Û	1.796	.029
174 170	4 71	1	0	0	0	0	0	1.865	046
174	4	1	0	0	0	0	0	1.925	.0/5
174	4	1	õ	õ	ŏ	õ	õ	- 045	- 121
174	4	1	Ō	Ō	ō	Ō	Ŭ	. 105	.412
174	4	1	0	0	0	0	0	.205	. 434
174	4	1	Û	0	0	0	Û	.279	• 383
174	4	3	0	0	6	0	0	• 369	.430
174	4	3	0	0	0	Ú	0	. 444	• 453
174	4	2	0	15	3	1	1	.539	.300
171	4 11	2	0	0	6	2	0	•025 702	• 424 272
174	-т Ц	.) ?	0	0	0	5 0	0	• 705 788	• 27 2
174	4	ר ק	ŏ	õ	2	õ	ŏ	- 888	. 369
174	4	ŝ	Ŏ	Õ	ō	õ	Õ	.948	.440
174	4	3	0	0	Ó	0	0	1.102	.485
174	4	1	Û	0	0	0	0	1.302	.529
174	4	1	Û	0	0	0	0	1.367	•503
174	4	1	0	0	0	0	0	1.436	• 331
174	4	1	0	0	0	0	0	1.471	•525
171	4	1	0	0	0	0	0	1.540	.420
171	4	2	0	0	0	0	0	1.000	• 30 I 37/I
174	4	ר. א	0	0	্য	0	0	1.746	. 421
174	4	ر ۲	Ŭ	õ	ŏ	ž	1	1.825	. 395
174	4	ž	Õ	Ō	Õ	2	Û	1.915	.344
174	4	1	0	0	0	0	0	1.970	.367
174	4	0	0	0	0	0	0	0.000	0.000
174	5	1	Û	0	0	0	Û	.035	0.000
174	5	1	0	0	0	0	0	.090	074
174	5	1	0	0	0	0	0	.200	074
171	5	1	0	0	0	0	0	.290	- 074
174	5	1	0	0	0	0	0	. 405	050
174	5	1	Ő	ŏ	Ö	õ	õ	. 460	099
174	5	2	Ō	Ŭ	õ	1	Ŭ	•535	074
174	5	1	0	0	0	0	0	.615	025
174	5	1	Û	Û	0	0	Û	.695	074
174	5	1	0	0	0	1	Û	.760	074
174	5	1	0	Û	0	0	0	.825	025
174	5	1	0	0	0	0	0	• 875 075	050
174	5	1	0	0	0	0	0	•975 MU	207
171	フ ち	1	0	0	0	0	0	120	• 391 272
174	5	1	ő	ŏ	õ	Ö	õ	. 199	.372
174	5	2	õ	õ	2	Õ	Õ	.269	.422
174	5	2	4	0	7	1	0	• 349	.422
174	5	2	0	0	0	0	1	. 449	• 397
174	5	2	0	0	0	Û	1	•549	. 422
174	5	3	0	0	0	0	0	.614	. 471
174	5	3	0	0	13	0	0	.684	.422

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174	5	3	Û	0	0	0	0	.749	.422
174	5	3	Û	0	3	0	0	.799	.446
174	5	2	0	0	0	1	0	.874	.422
174	5	1	0	0	0	Û	Û	•959	.546
181	1	1	0	0	0	0	0	.045	.022
181	1	1	0	0	0	0	0	.131	.016
181	1	1	0	0	0	0	Û	.211	.036
181	1	2	6	0	0	3	0	.287	.031
181	1	2	0	0	0	1	0	.373	.025
181	1	1	0	0	0	0	0	.463	.019
181	1	3	0	0	0	Ó	1	.539	.014
181	1	3	Ō	Ō	Ō	Õ	Ó	.624	.034
181	1	1	Ō	Ū	Ū	Ğ	Ū.	. 795	. ()22
181	1	1	õ	Ō	ō	õ	Õ	. 876	.017
181	1	1	õ	õ	ŏ	õ	õ	956	011
181	1	1	Õ	õ	ŏ	õ	õ	1.047	.030
181	1	1	Ō	Ó	ŏ	õ	õ	1 138	020
181	1	1	õ	õ	õ	õ	õ	1 213	024
181	1	1	õ	õ	õ	õ	ő	1 268	_ 012
181	1	1	ŏ	õ	ŏ	õ	0	1 201	- 012
181	1	ג	ŏ	ň	õ	õ	2	1 271	800
181	1	1	õ	õ	õ	ň	0	1 1/15	020
181	1	1	õ	õ	0	õ	0	050	-029 501
181	1	2	2	1	õ	2	0	121	105
181	1	2	0	0	Õ	õ	1	• 13 1	001
181	1	2	0	0	0	0	1	200	-490 500
181	1	2	0	0	ů Č	0	1	• 507	-509 501
101	1	.) 2	0	0	0	0	1	• 212	109
101	1	2	0	0	0	0	0	.405	• 490 1107
101	1	2	0	0	0	2	0	· U2 9 725	• 40 / 110 1
101	1	2	0	0	0	2	0	• (2)	• 40 I JI76
101	1	2	0	0	0	2	0	.000	.4/0
101	1	2	0	2	0	2	0	• 00 1	• 445 JIOC
101	1	2	0	S	0		0	• 900 1 007	.490
101	1	1	0	0	0	0	0	1.04/	• 5 09
101	1	1	0	0	0	0	0	1.120	.504
101	1	1	0	0	0	0	0	1.193	. 000
101	1	1	0	0	0	0	0	1.273	.4/0
101	1	1	0	0	0	0	0	1.314	.400
131	1	1	0	0	0	0	Ű	1.304	• 40Z
181			0	0	0	0	0	1.480	.455
181	0	0	0	0	0	0	0	0.000	0.000
181	2	1	0	U O	0	0	0	.005	027
181	2	1	0	0	0	Ŭ	0	. 146	029
181	2	1	0	0	0	0	0	.237	031
181	2	1	0	0	0	0	0	• 322	032
181	2	1	0	0	0	0	0	• 473	061
181	2	1	0	0	0	0	0	•554	037
181	2	1	0	0	0	0	0	• 635	012
181	2	1	0	0	0	0	0	.746	015
181	2	1	0	O	0	0	0	.816	016
181	2	1	0	0	0	0	0	.897	.009
181	2	3	0	0	0	0	0	•972	.007

<u>F</u>					.,		_		
181	2	1	0	0	0	0	0	1.043	.006
181	2	1	0	0	0	0	Ŭ	1.118	• 00 <i>1</i>
181	2	1	0	0	0	0	O	1.194	• 00 3
181	2	1	0	0	0	0	Ú	1.244	. 002
181	2	1	0	0	0	0	0	1.315	.000
181	2	1	0	0	0	0	0	.052	•547
181	2	3	0	0	0	0	0	. 153	•545
181	2	2	4	0	0	1	0	•239	.517
181	2	1	0	Û	0	0	0	.324	•542
181	2	1	Û	0	0	0	0	. 400	.512
181	2	1	2	0	Û	2	Û	. 475	.513
181	2	2	0	0	0	1	0	•566	.537
181	2	1	Ú	Û	0	Û	0	.647	•535
181	2	2	0	0	0	0	1	.727	.508
191	2	?	0	0	Ú	0	1	.813	.532
181	2	3	0	0	Û	Û	Û	.883	.557
181	2	3	Û	0	0	0	3	.959	.555
181	2	3	0	0	0	0	õ	1.035	.590
181	2	3	0	0	0	0	0	1.105	.579
181	2	3	0	0	Û	0	1	1.186	.577
181	2	1	0	Û	0	0	0	1.256	.576
181	2	1	Û	Ó	Ō	Ō	Ō	1.312	.575
181	Û	Û	Û	Ō	Ŭ	Ō	Ō	0.000	0.000
181	3	1	Ō	Õ	Õ	Ō	Õ	.050	028
181	à	1	Ō	Ō	õ	õ	Ō	. 136	007
181	ĩ	1	Ō	Ō	õ	1	Ō	.216	011
181	3	1	õ	õ	õ	Ó	Õ	. 306	016
181	3	1	õ	õ	õ	Õ	õ	.878	019
181	3	3	Õ	õ	Õ	Õ	ō	.963	- 021
181	3	ר ג	õ	õ	õ	Õ	ŏ	1,033	002
181	ר ק	ר א	Õ	Õ	ŭ	Ŭ.	Ğ	1,109	005
181	2	ר א	õ	õ	õ	õ	õ	1, 194	.016
181	2	2	õ	õ	õ	õ	õ	1.279	014
181	2	2	ŏ	õ	õ	õ	1	1 355	017
181	2	2	õ	õ	õ	ŏ	1	1 455	- 023
181	2	ר. א	õ	õ	õ	õ	1	1 535	- 027
181	ר. א	1	õ	õ	õ	õ	0	1.636	- 032
181	7	3	õ	õ	õ	ŏ	1	1 721	037
181	2	2	õ	õ	õ	õ	1	1 816	- 016
191	2	2	2	0	0	1	0	1 062	01
101	2	2	2	0 0	1	0	2	2 067	- 003
191	2	2	0	0	0	0	1	2 167	00_
191	2	2	0	0	0	0	1	2 232	- 012
101	.) 2	2	0	0	0	0	$\dot{0}$	2.232	- 012
101	2	2	0	0	0	0	0	2.310	- 020
101	3	2	0	0	0	0	1	2.403	
101	3	2	0	0	0	0	Å	2.000 2 601	- 021
101	3	5	0	0	0	0	1	2.004	- 03
101	3	5	0	0	0	0		2.094	U3: 011
101	5	5	0	0	0	0	0	C.117	- OI
101	5	1	0	0	0	0	0	2.000	043 020
101	5	1	0	0	0	0	0	2.71U	- UZ 609
181	3		U	0	U	0	U	•039	.00

Age Specific Data (continued	Age	Specific	Data	(continued)
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181	3	3	0	O	0	Ú	C	. 124	.629
181	3	3	0	0	0	0	Û	.210	.625
181	3	2	7	1	0	0	2	•932	.639
181	3	1	0	0	0	0	0	1.042	.633
181	3	1	0	0	0	0	0	1.639	.654
181	3	3	0	0	0	0	0	1.730	.675
181	3	1	0	0	0	0	U O	2.874	.591
181	3		0	0	0	0	0	2.959	.638
101	0	0	0	0	0	0	0	0.000	0.000
101	4	2	0	3	0	0	1	•038 710	.025
101	4)i	2	0	0	0	0		• (19	.000
101	-т Л	2	0	0	0	0	0	•//4	.000
191	- л	2	0	0	0	0	1	•029 905	• UZO
181	ч	1	0	0 6	6	6	Ċ.	• 095	- (125
181	Ц	1	0	õ	0	0	0	.905	029
181	ц Ц	1	ŏ	õ	õ	ŏ	õ	116	550
191	4	1	õ	Ő	õ	ŏ	õ	196	• JJ9 585
181	4	1	Ő	ó	ŏ	õ	ŏ	.276	.534
181	4	1	õ	ŏ	õ	õ	õ	.362	.534
181	4	1	õ	õ	õ	õ	õ	.442	.534
181	4	1	Ō	Ō	Ō	Ō	Ō	.523	.559
181	4	1	2	0	0	0	Ŭ	.593	.534
181	4	1	Ú	Û	0	0	0	.673	•534
181	4	1	0	0	0	0	0	.759	.559
181	4	1	0	0	0	0	0	.834	•559
181	4	1	0	0	Û	Û	Û	.915	•559
181	4	1	Û	0	0	0	Ú	.975	•585
181	Û	0	Û	0	0	0	Ú	0.000	0.000
181	5	1	Û	0	0	0	0	.050	.002
181	5	1	0	0	Ó	0	0	. 150	.031
181	5	1	0	0	0	0	0	.245	.008
181	5	1	0	0	0	0	0	• 325	.011
181	5	3	0	0	0	5	Ŭ O	. 455	.015
181	5	1	0	0	0	0	0	.000	.040
101	5	1	0	0	0	0	0	• (15	.050
101	2 E	.5	0	0	0	2	0	.005	•053 056
101	2 E	1	0	0	2	2	0	• 090 070	• UOU 000
101	5	ے 1	0	0	С. О	4	0	1 060	036
181	5	2	0	1	10	0	1	1 105	015
181	5	2	0	Ġ	6	ů.	Ġ	1 205	.019 (18
181	5	.) 1	õ	0	0	õ	ň	1,420	.048
181	5	1	õ	ŏ	1	1	õ	1.500	.051
191	5	2	7	õ	ג	2	õ	1.615	.029
181	5	2	0	Ő	ŏ	ō	2	1.755	.059
181	5	3	Õ	Ō	Ō	Ō	Ō	1.915	.065
181	5	ŝ	0	0	0	0	1	2.030	.069
181	5	3	0	0	0	0	0	2.160	.073
181	5	3	0	0	Û	0	0	2.280	.052
181	5	ž	0	0	0	2	0	2.415	.056
181	5	2	0	0	1	0	0	2.545	.035

Age	Specific	Data	(continued)
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$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$
2.725 2.790 2.875 2.960 .051 .126 .221 .311 .461 .581 .706 .811 .971 1.056 1.136 1.211 1.301 1.371 1.456 1.631 1.711 1.796 1.866 1.956 2.036 2.136 2.306 2.376 2.471 2.541	2.541 2.641 2.721 2.796 2.866 2.956	0.000 1.178 1.293 1.464 2.055 2.140 2.306
000000000000000000000000000000000000000		
	0 0 0 0 0	
	0 0 0 0 0	0 0 0 0 0
000000000000000000000000000000000000000	0 0 0 0 0	0 0 0 0 0
313111333213331111111111111111111111111	1 1 1 1 1	0 1 1 1 1 1
うちちちちちちちちちちちちちちちちちちちちちちちちちちちちちちちちち	5555555	0 0 0 0 0 0 0
181 181 181 181 181 181 181 181 181 181	181 181 181 181 181 181 181	181 181 181 181 181 181 181

181	6	1	0	0	0	0	0	3.464	032
181	6	1	0	0	Ú	Ú	Ú	3.549	031
181	6	1	0	0	0	0	0	.047	•535
181	6	3	0	0	0	0	1	• 298	•538
181	6	3	Û	0	0	0	1	• 368	•539
181	6	3	Û	0	0	0	1	• 463	•565
181	6	3	Û	Û	0	0	1	•539	•541
181	6	3	0	0	0	0	1	.629	•593
181	6	1	0	0	0	0	Û	.960	•546
181	6	3	0	0	0	0	0	1.065	.547
181	6	3	Û	0	Û	Û	0	1.185	•549
181	6	1	3	0	0	1	0	1.306	•551
181	5	2	0	0	0	0	3	1.456	•552
181	6	3	0	0	1	Û	0	1.771	.607
181	6	1	0	0	0	0	0	2.283	.512
181	6	1	Ú	0	0	0	Û	2.388	•539
181	6	1	0	0	0	С	0	2.339	.513
181	6	3	0	0	0	0	0	2.709	•518
181	6	1	0	O	0	0	0	2.950	.521
181	6	1	0	0	0	0	0	3.065	•547
181	6	1	0	0	0	0	0	3.150	•523
181	6	1	2	0	C	0	O	3.256	.524
181	6	2	6	0	0	2	0	3.401	•526
181	6	2	0	0	1	0	0	3.526	•553
181	6	2	3	0	0	3	0	3.642	•504
181	6	2	2	0	2	5	0	3.797	•557
181	6	3	0	Ó	0	0	Ó	3.952	•559
181	6	1	0	0	0	0	0	4.075	.050
181	6	1	0	0	Û	Û	Ú	4.140	055
181	6	1	0	0	0	0	0	4.216	057
181	5	1	0	0	0	0	0	4.291	034
181	6	1	0	0	0	0	0	4.406	038
181	6	1	0	0	0	0	0	4.472	015
181	6	1	0	0	0	0	0	4.56%	043
181	6	1	0	0	0	0	0	4.652	071
181	6	1	0	0	0	0	Ŭ	4.718	.003
181	6	1	0	0	0	0	0	4.798	025
181	6	1	0	0	0	0	0	4.8(8	028
181	6	1	0	0	U C	0	0	4.904	030
181	5	1	0	0	0	0		5.084	009
181	6	3	0	0	0	0	0	5.205	.012
181	5	2	0	0	0	0		5.410	.000
181	0	1	0	0	0	0	0	5.040	001
181	D C	1) 6	0	0	0	0	5.002	.019
101	D ∠	1	0	U C	0	0	0	2.761 6 mm 2	.040
101	D	1	0	U A	U A	U C	0	0.005	ווט. ווכח
101	D 4	1	0	U C	U A	U A	0	0.133	•U34 A21
101	D 4	1	0	0	0	0	0	6 2011	.051
101	0	1	0	0	0 A	0	0	0.004 6 JIC II	- M3
101	0	1	0	0	0	0	0	6 570	002 - MAE
101	0 4	1	0 A	0	0	0	0	6 655	_ 009
101	U	1	0	0	U	0	0	0.000	005

181	6	1	0	0	0	0	0	6.735	.015
181	6	1	0	0	0	0	0	6.936	042
181	6	1	0	0	0	0	0	7.046	121
181	D (1	0	0	0	0	0	7.051	.030
101	D (1	0	U G	0	U	Ŭ	7.147	.027
101	D 4	1	U C	0	0	Ŭ	0	7.232	.024
101	0	1	0	0	0	0	0	7.322	004
101	0	1	0	0	0	0	0	7.423	.018
101	6	1	0	0	0	0	0	1.593	038
101	6	1	0	0	0	0	0	7.910	040
191	6	1	0	0	0	0	0	7.075	.000
181	6	1	0	0	0	0 0	0	1.056	-007 502
191	5	1	0	0	0	0	0	4.055	- 502 500
191	6	1	õ	0	0	0	0	4.120 1.217	- 500 522
181	6	1	õ	õ	ő	ñ	0 0	L 307	·)2) 105
181	6	1	õ	õ	õ	õ	0	<u>л</u> л05	
181	6	1	ŏ	õ	õ	õ	õ	4.478	. 489
181	6	1	ŏ	õ	õ	õ	õ	4,558	.512
181	6	1	õ	õ	õ	õ	ŏ	4,653	484
181	6	1	õ	õ	õ	õ	õ	4.724	481
181	6	1	Ō	Õ	Ō	Õ	Õ	4.799	.504
181	6	1	8	Û	0	0	0	4.894	.501
181	6	2	5	Ŭ	0	1	Ŭ	4.930	. 499
181	6	1	Ō	Û	0	0	Û	5.080	495
181	6	2	Û	0	Û	0	1	5.210	. 491
181	6	1	Û	O	0	Û	0	5.421	. 485
181	6	1	0	Û	0	0	Û	5.557	.506
181	6	1	0	0	0	Û	Û	5.712	.501
181	6	1	Û	Û	0	Û	0	6.049	.515
181	6	3	0	0	0	0	1	6.134	•513
181	6	3	0	0	0	0	1	6.194	.486
181	6	3	0	0	0	0	1	6.269	•534
181	6	2	0	2	0	0	3	6.460	. 477
181	6	3	0	0	0	0	0	6.646	•522
181	6	3	Û	0	0	0	1	6.726	.519
181	6	3	0	0	0	0	0	6.801	.517
181	6	1	U O	U O	U O	0	U O	6.957	•537
181	6	3	0	0	0	2	0	7,4()4	. 624
181	6	2	2	U O	0	1	0	7.504	•594
131	0	1	·)	0	U C	0	U C		•591
101	0	1	U C	0	0	0	0	(•(())	• 707
101	D C	1	0	0	0	0	0	0.290	017
101	0	1	0	0	0	0	0	0.447	017
101	0	1	0	0	0	0	0	0.0/D 8 705	.000
101	0	1	0	0	0	0	0	0.100	020
101	0 6	1	0	0	0	0	0	0 220	012
101	6	1	0	0	0	0	0	9.220	010 011
101	6	1	0 A	0	0	0	0	0 205	_ 022
181	6	1	0	0	0	0	ů ů	9.575	022
181	6	1	õ	õ	õ	õ	õ	9.705	063
101	0	1	0	0				20102	••••

607 .019 014 077 021 024 024 029 034 .014 .039 026 .649 .645 .642 .639 .659 .659 .659 .659 .673 .729 .724 .750 .684 .734 .752 .747 .682 .738 .731 .696 .723 .747 0.000 025 .550 .525 .525 .
9.800 9.880 9.975 10.070 10.160 10.250 11.070 11.220 11.310 11.900 8.300 8.395 8.655 8.805 9.075 9.075 9.300 9.950 10.060 10.280 9.950 10.060 10.430 10.530 10.640 10.530 10.640 10.720 10.970 11.890 12.290 12.450 12.620 12.780 12.690 12.950
000000010000000000000000000000000000000
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1 1 1 1 3 1 1 1 3 3 1 1 1 1 1 1 1 1 1 1
\$
$\begin{array}{c} 181\\ 181\\ 181\\ 181\\ 181\\ 181\\ 181\\ 181$

Age S	pecific	Data	(cont	inued)				
18	<u> </u>	1	0	0	0	0	0	1.050	482
18	8 1	4	0	0	0	0	0	1.251	485
180	8 1 D 1	3	0	0	0	0	1	1.462	464
18	5 1	1	U O	0	0	0	0	1.557	465
100	5 I 9 1	1	0	0	0		0	1.732	468
100	D I D 1	1	0	0	0	0	0	1.003	470
18	2 I R 1	1	0	0	0 0	0	0	1.9/5	4/2
199	2 I	1	0	0	0 0	0	0	2.149	- 176
18	, 1	1	õ	Ő	õ	õ	0	2 269	- 351
18	8 1	1	ŏ	ŏ	õ	õ	ŏ	2.390	- 403
18	B 1	1	Ō	Ō	Ō	Ō	Ō	2.540	456
18	3 1	1	0	0	0	0	0	2.645	453
18	31	1	C	0	0	0	0	2.756	435
188	31	1	Û	0	0	О	Ú	2.816	461
18	3 1	2	0	0	0	O	0	2.957	438
18	<u> </u>	4	0	0	0	0	0	3.102	441
18	3 1	1	0	0	0	0	0 Ô	3.323	495
180		4	0	0	0	0	U C	3.463	447
100	5 I 2 1	4	0	0	0	0	1	3.594	449
189	2 I) 1	0	0	0	0	ċ	3. (14	4/0
189	2 I	і Ц	0	0	0	0	0	5.945 1 GQ5	400
189	R 1	1	0	ů ů	0	õ	õ	1 231	• <u>))</u> 528
189	3 1	1	õ	ŏ	ŭ	ŭ	ŭ	1.371	.551
188	3 1	1	õ	õ	Ō	õ	Õ	1.587	.547
188	3 1	4	0	0	0	Ō	1	1.753	.544
18	3 1	4	0	0	0	0	2	1.933	.516
188	3 1	4	Û	0	0	Û	0	2.089	•539
18	3 1	2	10	9	0	0	2	2.234	.511
18	3 1	4	O	0	0	0	1	2.430	•533
188	3 1	4	0	0	0	0	0	2.580	•530
188	3 1	1	0	0	0	0	0	2.701	.525
180	5 1	1	U C	U C	0	0	0	2.791	•527
100	5 I 5 1	1	0	0	0	0	0	2.000	• 520 521
18	י ו ג 1	і Д	0	0	0 0	0 G	2	2.952	• 524 106
189	2 I	2	0	2	२	1	ō	3, 328	.518
18	3 1	้ว	õ	ō	õ	, 0	Ž	3,458	.516
18	<u>3</u> 1	4	ں م	Ō	Ō	Ō	1	3.599	.513
18	3 1	4	0	0	0	0	1	3.769	.510
188	3 1	1	0	Û	0	0	0	3.950	•533
18	31	2	0	0	0	0	1	4.046	507
18	8 1	4	0	0	0	0	0	4.243	509
18	B 1	1	Û	0	0	0	0	4.373	536
188	3 1	1	0	0	0	0	0	4.444	512
18	5 1	1	0	0	0	0	0	4.534	513
18	5] o 4	1	0	U A	U A	0	0	4.034 11 661	041
100	D I D 1	 2	U A	0	0	0	с 0	4.00 // 2/11	-, 500
100	י ד ג ג	5)i	0	0	0	0	n N	5 062	- 110
18	ς ι R 1	2	0	0 0	ő	0	1	5,214	
1.05			~	-	-	-			

$\begin{array}{cccccccccccccccccccccccccccccccccccc$	183	1	3	0	0	0	0	1	5,355	- 524
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	188	1	3	0	0	0	0	0	5.637	476
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	189	1	4	0	0	O	0	0	5.748	453
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	188	1	4	0	0	0	0	Û	5.924	429
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	188	1	4	0	0	0	0	0	6.084	492
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	188	1	3	C	0	0	Û	0	6.256	459
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	188	1	4	0	0	0	0	O	6.432	461
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	199	1	4	0	0	0	0	1	6.598	438
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	188	1	4	0	0	0	0	0	6.784	491
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	188	1	1	0	0	0	0	0	6.959	544
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	188	1	1	0	0	0	0	0	7.065	520
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	155	1	3	9	<u>)</u>	0	0	0	7.297	497
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	188	1	4	U C	0	0	U C	0	7.443	499
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	100	1	4	U C	0	0	U C	U O	7.594	501
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	100	1	4	0	0	0	0	0	7.775	504
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	100	1	4	0	0	0	0	0	(+935	550
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	100	1	1	0	0	0	0	0	4.044	- 455 1170
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	192	1	4	0	0	0	0	0	4.240	- 4/5 176
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	188	1	1	0	0	0	0	0	4.391	.4/0 175
183 1 0 0 0 0 446 183 1 0 0 0 0 446 188 1 1 0 0 0 446 188 1 1 0 0 0 446 188 1 1 0 0 0 5.075 .493 188 1 1 0 0 0 0 5.211 .491 188 1 1 0 0 0 0 5.211 .491 188 1 1 0 0 0 0 5.347 .515 183 1 2 0 0 0 5.553 .461 183 1 2 0 0 1 5.740 .510 183 1 2 0 0 1 6.102 .505 183 1 3 0 0 0 6.505 .525 183 1 3 0 0	188	1	и И	0	0	0	0	0	4.450	-4/5
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	188	1	1	0	0 G	0	0	0	4.597	• 499 1116
188 1 1 0 0 0 0 5 (775) .493 188 1 1 0 0 0 0 5.211 .491 188 1 1 0 0 0 0 5.347 .515 188 1 1 0 0 0 0 5.438 .4493 188 1 1 0 0 0 0 5.553 .461 183 1 2 0 0 0 5.644 .486 183 1 2 0 0 1 5.740 .510 133 3 0 0 0 1 6.102 .505 183 1 4 0 0 0 6.424 .501 183 1 3 0 0 0 6.555 .525 183 1 3 0 0 0 6.655 .473 183 1 1 0 0 0 7	188	1	1	õ	0	0	0	0 0	4.795	.440 101
183 1 0 0 0 0 5.211 .491 188 1 1 0 0 0 0 5.247 .515 183 1 1 0 0 0 0 5.483 .483 183 1 1 0 0 0 0 5.553 .461 183 1 2 2 0 0 0 5.644 .486 183 1 2 0 0 0 5.644 .486 183 1 2 0 0 1 5.740 .510 183 1 4 0 0 0 1 6.102 .505 188 1 4 0 0 0 6.424 .501 188 1 3 0 0 0 6.555 .525 183 1 0 0 0 0 6.655 .473 188 1 0 0 0 0 7.304	188	1	1	õ	0 0	ŏ	ŭ	6	5 (75	-דרי 201
188 1 1 0 0 0 0 5.211 .191 188 1 1 0 0 0 0 5.347 .515 183 1 1 0 0 0 0 5.488 .483 183 1 1 2 0 0 0 5.553 .461 183 1 2 2 12 0 0 1 5.740 .510 183 1 2 2 12 0 0 1 6.102 .505 183 1 4 0 0 0 0 6.278 .478 183 1 3 0 0 0 0 6.505 .525 183 1 3 0 0 0 0 6.746 .497 183 1 0 0 0 0 7.304 .465 183 1 0 0 0 0 7.335 .489 183 1<	188	1	1	õ	ŏ	õ	õ	0	5 211	• - Э.Э. ЦО 1
183 1 1 0 0 0 0 5.438 .483 183 1 1 0 0 0 0 5.553 .461 183 1 1 2 0 0 0 5.543 .483 183 1 2 0 0 0 5.644 .486 183 1 2 2 12 0 0 1 5.740 .510 183 1 3 0 0 0 1 6.102 .505 183 1 4 0 0 0 1 6.102 .505 183 1 4 0 0 0 6.6278 .473 183 1 3 0 0 0 6.655 .473 183 1 3 0 0 0 6.655 .473 183 1 1 0 0 0 7.663 .469 183 1 1 0 0 0<	188	1	1	ŏ	õ	ŏ	õ	õ	5.347	.515
183 1 1 0 0 0 0 5.553 .461 183 1 1 2 0 0 0 5.544 .486 183 1 2 2 12 0 0 1 5.740 .510 183 1 3 0 0 0 3 5.916 .482 183 1 4 0 0 0 1 6.102 .505 188 1 4 0 0 0 0 6.278 .478 183 1 3 0 0 0 6.424 .501 183 1 3 0 0 0 6.505 .525 183 1 3 0 0 0 6.457 .469 183 1 0 0 0 0 7.364 .469 183 1 0 0 0 0 7.364 .469 183 1 0 0 0 0 </td <td>188</td> <td>1</td> <td>1</td> <td>ŏ</td> <td>õ</td> <td>õ</td> <td>õ</td> <td>ŏ</td> <td>5.488</td> <td>483</td>	188	1	1	ŏ	õ	õ	õ	ŏ	5.488	483
183 1 2 0 0 0 5.644 .486 183 1 2 2 12 0 0 1 5.740 .510 183 1 3 0 0 0 3 5.916 .482 183 1 4 0 0 0 1 6.102 .555 188 1 4 0 0 0 0 6.424 .501 183 1 3 0 0 0 0 6.505 .525 183 1 3 0 0 0 0 6.655 .473 183 1 3 0 0 0 0 6.746 .497 183 1 1 0 0 0 0 6.957 .469 183 1 1 0 0 0 7.304 .465 183 1 1 0 0 0 7.335 .489 183 1 0 0 </td <td>189</td> <td>1</td> <td>1</td> <td>õ</td> <td>õ</td> <td>õ</td> <td>õ</td> <td>õ</td> <td>5,553</td> <td>.461</td>	189	1	1	õ	õ	õ	õ	õ	5,553	.461
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	188	1	1	2	Ō	Ō	Ō	Ō	5.644	. 486
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	188	1	2	2	12	O	0	1	5.740	.510
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	188	1	3	0	0	0	0	3	5.916	.482
1881400006.278.478 133 1300006.424.501 189 1300006.505.525 133 1300006.655.473 183 1300006.746.497 183 1100006.957.469 183 1100007.063.453 183 1100007.304.465 183 11090107.335.489 183 1100017.541.512 183 1100007.973.456 183 1400008.093479 183 1400008.254460 188 1400008.565496 188 1400008.766529 188 1400008.912509 188 1400009.249547 188 1400009.249547	188	1	4	0	0	0	0	1	6.102	.505
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	188	1	4	C	Ú	0	0	0	6.278	. 479
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	188	1	3	0	Û	0	0	0	6.424	.501
18313000006.655.473 183 13000006.746.497 183 11000006.957.469 183 11000007.063.463 183 1100007.304.465 183 11090107.335.489 183 1200017.541.512 183 1400007.973.456 183 1400008.093479 183 1400008.254460 188 1400008.766529 183 1400008.766529 183 1400008.766529 183 1400008.912509 183 1400009.249547 183 1400009.249547	189	1	٦	0	0	0	0	0	6.505	•525
19313000006.746.497 183 11000006.957.469 183 11000007.304.465 183 11090107.385.489 183 11090107.385.489 183 1200017.541.512 183 14000017.762.459 183 1400008.093479 183 1400008.254460 188 1400008.254460 188 1400008.766529 183 1400008.766529 188 1400009.249547 188 1400009.249547	188	1	3	Û	0	0	Û	U	6.655	.473
18311000006.957.469 183 11000007.063.463 183 11090107.304.465 183 11090107.385.489 183 1200017.541.512 183 1400017.762.459 183 1100007.973.456 183 1400008.093479 183 1400008.254460 188 1400008.565496 188 1400008.766529 188 14000028.912509 188 1400009.249547 188 1400009.249547	188	1	3	0	0	0	0	0	6.746	. 497
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	188	1	1	0	0	0	0	0	6.957	. 469
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	188	1	1	0	0	0	0	0	7.059	.459
18311090107.355.489 183 12000017.541.512 183 14000017.762.459 183 11000007.973.456 183 14000008.093479 183 14000008.254460 188 1400008.410490 188 1400008.565496 188 1400008.766529 188 14000028.912509 188 1400009.249547	188	1	1	0	0	0	0	0	7.304	.465
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	188	1	1	0	9	0	1	0	7.385	.489
185 1 4 0 0 0 0 1 7.762 $.459$ 188 1 1 0 0 0 0 0 7.973 $.456$ 188 1 4 0 0 0 0 8.093 479 183 1 4 0 0 0 0 8.093 479 188 1 4 0 0 0 0 8.254 460 188 1 4 0 0 0 0 8.410 490 188 1 4 0 0 0 0 8.565 496 188 1 4 0 0 0 8.912 509 188 1 4 0 0 0 9.249 547 188 1 4 0 0 0 9.249 547	175	1	2	0	0	0	0	1	(.54)	-512
183 1 1 0 0 0 0 0 7.973 $.450$ 188 1 4 0 0 0 0 0 8.093 479 188 1 4 0 0 0 0 8.254 460 188 1 4 0 0 0 0 8.410 490 188 1 4 0 0 0 0 8.565 496 188 1 4 0 0 0 0 8.766 529 188 1 4 0 0 0 2 8.912 509 188 1 4 0 0 0 0 9.688 491 188 1 4 0 0 0 9.249 547	100	1	4	0	0	0	0	1	7.072	• 409 1156
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	100	1	1	0	0	0	0	0	8 003	- 450 - 1170
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	100	1	4	0	0	0	0	0	8 251	- 460
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	199	1	- Д	0	0	0	0	0	8 <u>410</u>	- 400
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	188	1	ц	0	0	0	0	0	8.565	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	188	1	ц Ц	ñ	õ	ñ	Õ	õ	8.766	- 529
188 1 4 0 0 0 1 9.088 491 188 1 4 0 0 0 0 9.249 547	188	1	Ц	õ	ŏ	õ	õ	Ž	8,912	- 509
183 1 4 0 0 0 0 0 9.249547	188	1	4	õ	õ	ũ	ŭ	1	9.088	- 491
	188	1	4	Ō	Ō	Ō	Ō	0	9.249	547

188	1	3	0	0	0	0	3	9, 394	- 527
188	1	2	ñ	ň	õ	ñ	õ	0 505	- 521
100	1	2	õ	0	0 0	0	ĥ	9.000	
100	1	5	0	0	0	0	3	9.040	512
188	1	3	0	0	0	0	0	9.776	51?
188	1	4	Û	Û	0	0	0	9.937	473
188	1	4	0	0	0	0	0	8,093	407
1 8 8	1	1	Ň	õ	õ	õ	õ	8 32H	516
100	4	4	~	~	0	0	0	0.204	.510
158	1	1	U	0	0	U	0	8.304	•539
188	1	1	0	0	0	0	0	8.435	.484
188	1	3	0	0	0	0	0	8.560	.504
188	1	2	0	4	0	9	0	8.641	.501
188	1	1	Û	0	0	Ó	Ó	8.751	497
188	1	1	Ň	õ	õ	õ	õ	8 817	510
100	4	1	Š	0	Š	0	0	0.017	-519
100	1	1	0	0	0	0	0	8.9//	.513
188	1	4	0	0	0	0	0	9.113	•558
188	1	4	0	0	0	0	0	9.259	.503
188	1	1	0	0	0	1	0	9.375	.549
188	1	1	0	0	<u>6</u>	Ó	Ó	9,485	519
188	1	1	Š	1	1	õ	1	0 565	516
100	1	1	2	, ,	, ,	0		9.505	.510
150		1	0	0	0	0	0	9.0/1	•53/
185	1	2	2	1	2	5	2	9.782	•533
188	1	1	0	0	0	0	0	9.977	.501
188	0	0	0	0	Ú	Ú	Û	0.000	0.000
188	2	1	0	0	0	0	0	.040	484
188	2	1	0	0	0	0	0	. 111	- 489
188	2	1	1	õ	õ	õ	ñ	221	- 523
199	2	1	0	õ	0	õ	õ	202	
100	2	2	0	0	0	0	1	· 502	19
100	2	2	0	0	0	0		• 548	49/
188	2	3	0	0	0.	0	0	.003	455
188	2	1	0	0	0	0	0	•794	516
188	2	1	0	0	0	0	0	•889	498
188	2	1	Ú	0	0	0	0	.970	504
188	2	4	0	0	0	0	0	1.106	-, 489
199	2	1	Õ	Õ	Õ	õ	Ō	1 302	- 504
100	2	2	1	õ	õ	õ	õ	1 207	- 1186
100	2	2		0	0	0	0	1.591	400
100	2	1	0	U	0	0	0	1.503	494
188	2	1	0	0	0	0	0	1.578	500
188	2	3	с,	0	4	0	2	1.633	 504
188	2	3	Û	0	0	0	2	1.724	511
188	2	4	0	0	0	0	1	1.940	527
188	2	1	0	0	0	0	0	.045	.503
188	2	1	õ	õ	Õ	Õ	õ	. 116	498
100	2	1	õ	õ	õ	ň	õ	206	516
100	2	1	0	0	0	0	0	.200	• J10
185	2	1	0	0	0	0	0	.201	.510
188	2	1	0	0	0	0	0	• 377	.503
188	2	1	0	0	0	0	0	• 457	• 497
188	2	1	0	0	0	0	0	•553	. 490
188	2	1	0	0	0	0	0	.628	. 484
188	2	ц.	Ō	Ō	Ô	Ō	0	.779	498
188	2	л	ň	õ	ŏ	õ	ñ	025	<u>1</u> 61
100	2	-4 Ji	0	0	0	~	0	1 005	
100	2	4	U A	0	U A	0	0	1.097	• 477
188	-2	1	υ	U	U	U	U	1.201	•213

Age Specific I	Data (continued)
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. 499 . 502 . 538 . 538 . 555 . 555	•)0
$\begin{array}{c} 1.432\\ 1.638\\ 1.688\\ 1.764\\ 1.809\\ 1.910\\ 1.965\\ 0.0074\\ .193\\ .263\\ .397\\ .482\\ .557\\ .771\\ .931\\ 1.005\\ 1.105\\ 1.105\\ 1.209\\ 1$	110.01
000000000000000000000000000000000000000	•
000000000000000000000000000000000000000	
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000000000000000000000000000000000000000	0
000000000000000000000000000000000000000	0
4 1 1 1 1 1 1 1 1 0 4 1 1 1 2 2 3 2 1 1 1 2 3 1 1 1 1 1 1 1 1	1
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188 188 188 188 188 188 188 188 188 188	100

188	3	1	0	0	0	Ú	0	1.372	•550
188	3	1	Û	0	0	0	Ú	1.447	•547
188	0	0	Û	0	0	0	Û	0.000	0.000
188	4	1	Ú	Ú	Ú	Ú	Ú	.043	498
188	4	1	0	0	0	0	0	. 103	514
188	4	1	0	0	0	0	U	. 194	538
199	4	1	0	0	0	0	U	.275	533
188	4	2	Û	0	0	0	Ú	• 386	587
188	4	3	0	0	0	0	Û	. 496	642
188	4	3	C	0	0	U	0	•582	613
189	4	3	0	0	U	0	U	.683	665
188	4	3	C	0	0	0	Û	.789	692
188	4	1	Û	0	0	0	0	. 880	716
188	4	2	0	0	0	Û	0	1.021	753
188	4	1	0	0	0	0	0	1.132	781
188	4	1	Û	0	0	0	Û	1.207	775
188	4	1	0	0	0	Û	Û	1.323	754
188	4	2	Û	0	0	0	U	1.454	840
183	4	1	Û	0	0	0	0	1.580	847
188	4	1	Ú	0	Û	0	0	1.731	912
183	4	1	0	0	0	0	0	1.857	970
189	4	1	0	0	0	O	0	1.968	973
188	4	1	0	0	0	0	0	2.044	-1.018
188	4	1	0	0	0	0	0	2.134	-1.042
188	4	1	0	Û	0	0	0	.113	.432
188	4	4	0	0	0	0	2	.259	. 394
188	4	1	0	0	0	0	O	. 466	. 366
188	4	4	0	0	0	0	2	.582	.310
188	4	1	0	0	0	0	0	.663	.288
188	4	1	0	Û	0	0	Û	.789	.282
188	4	4	Û	Ú	Ú	Ú	3	. 925	.247
188	4	4	0	0	Û	0	2	1.105	225
189	4	4	0	Û	0	Û	Û	1.263	. 185
133	4	4	0	0	O	0	1	1.439	. 164
188	4	4	0	0	0	Û	3	1.590	.099
188	4	4	Ú	0	0	0	1	1.757	.082
188	4	4	0	0	0	Ú	0	1.933	.036
183	4	4	0	0	0	0	2	2.099	007
188	0	U	0	0	C	O	O	0.000	0.000
188	5	1	0	0	0	0	0	.055	509
183	5	1	0	0	0	0	0	. 136	539
188	5	3	0	0	0	0	1	.221	568
188	5	3	0	0	0	0	1	.311	547
188	5	3	0	O	0	Û	0	. 391	552
188	5	3	Û	O	0	0	Û	.467	530
188	5	3	0	0	0	0	0	.562	560
188	5	3	0	0	0	0	0	.652	565
188	5	4	0	0	0	0	0	.763	545
188	5	1	Ō	0	0	0	0	.953	555
188	5	1	Ō	0	0	0	0	1.048	534
188	5	1	Ō	Ō	Ō	Ō	0	1.144	564
188	5	1	Ō	Ō	Ō	0	0	1.244	544

Age	Spe	cific	Data	(cont	inued)					
	188	5	1	0	0	0	0	0	1.400	552
	188	5	1	0	Ú	Ú	Ú	Ú	1.475	556
	188	5	1	0	0	0	0	0	.055	•554
	188	5	1	Û	0	0	Û	0	<b>.1</b> 10	.551
	189	5	1	0	0	0	0	Û	. 191	•547
	188	5	1	0	0	0	0	0	.266	.518
	188	5	1	0	0	0	Ú	Û	.336	.540
	188	5	1	Û	0	0	Ú	0	.431	.510
	188	5	1	O	0	0	Û	0	.512	.506
	188	5	1	0	0	0	0	0	.602	.501
	188	5	1	0	0	0	0	Û	.662	•523
	188	5	1	Û	0	0	0	0	.717	•546
	188	5	1	0	0	0	0	0	<b>.</b> 803	•542
	188	5	1	0	0	0	0	0	<b>.</b> 858	.514
	188	5	1	0	0	0	0	0	•943	•509
	188	5	3	0	0	0	0	1	<b>• 9</b> 88	.507
	188	5	2	0	0	0	0	1	1.064	• 453
	183	5	1	C	0	0	0	0	1.129	.500
	188	5	1	0	0	0	0	0	1.189	. 497
	183	5	1	0	0	0	0	0	1.294	.567
	188	5	1	0	0	0	0	0	1.380	•563
	188	0	0	0	0	0	0	0	0.000	0.000
	188	6	1	0	0	0	0	Û	.044	565
	188	6	1	0	0	0	0	0	. 105	<b></b> 592
	188	6	1	0	0	0	0	0	. 135	439
	188	6	1	0	0	0	0	0	.231	519
	188	6	1	Û	Û	Ú	0	O	. 302	495
	188	6	1	Û	Û	0	0	Û	.402	651
	188	6	2	0	Ú	Ú	1	6	• 393	318
	188	6	1	0	0	0	0	0	.519	424
	188	6	2	Q	0	1	0	2	.610	426
	139	5	1	0	0	0	0	0	.696	377
	188	6	1	0	0	0	0	Û	.736	506
	188	6	1	0	0	0	0	0	.807	457
	188	6	4	0	0	0	0	0	•923	485
	183	6	1	0	0	0	0	0	.042	.512
	188	6	1	0	0	0	0	0	. 107	•530
	188	6	1	0	0	0	0	0	. 142	• 381
	188	6	1	0	0	0	U	0	. 198	.2(1
	133	D C	1	0	0	0	0	U O	.208	. 455
	188	D C	1	0	0	0	0	U O	.204	. 450
	188	b (		0	0	0	0	0	• 305 hr 1	.4/3
	138	5	1	0	0	0	0	0	• 45 I	.4/0
	188	D (	1	0	0	0	0	U	•23/	• 499 1170
	100	D C	1	0	0	0	0	0	• <b>7</b> 92	-4/2 206
	188	D C	1	0	0	0	0	0	·073	.490
	100	D	1	Ŭ	Ŭ	0	U C	U A	• (13	•72U
	100	D 4	1	U	U	0	U A	U A	• Ö24	- 440 127
	100	D ∠	1	U C	U C	0	U A	0	• 940 025	• 431 EDD
	100	Ō	4	0	U	0	0	0		000.0
	100	Ŭ	U	Ŭ	U	0	0	U C		U.UUU 540
	192	1	1	U	U	υ	U	U	.049	209

572 572 55824 55824 55824 55824 55824 
$\begin{array}{c} .130\\ .226\\ .307\\ .377\\ .453\\ .052\\ .128\\ .213\\ .299\\ .375\\ .441\\ 0.000\\ .080\\ .162\\ .259\\ .366\\ .468\\ .058\\ .149\\ .236\\ .302\\ .399\\ .476\\ .051\\ .142\\ .277\\ .457\\ .778\\ .918\\ 1.073\\ 1.248\\ 1.449\\ 1.594\\ 1.749\\ 1.914\\ 2.100\\ 2.260\\ 2.410\\ 2.591\\ 2.736\\ 2.961\\ .089\\ .249\\ .504\\ .615\\ .780\\ .960\\ 1.090\\ 1.246\\ 1.371\end{array}$
000000000000000000000000000000000000000
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12111111111011221111111111444443414444444444
777777777708888888888888111111111111111
$\begin{array}{c} 189\\ 188\\ 188\\ 188\\ 188\\ 188\\ 188\\ 188\\$

1.601       .56         1.746       .56         1.887       .56         2.092       .57         2.247       .55         2.418       .55         2.558       .56         2.768       .56         2.878       .56         2.962       .57	1. 1. 2. 2. 2. 2. 2.	000000000000000000000000000000000000000					4 1 1 4 1 4 4 1 1	1 1 1 1 1 1 1 1 1	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	0.	0 0 0 0 1 0 0	0 0 0 0 0 1 0 0	0000000000	000000000000000000000000000000000000000	000000000000000000000000000000000000000	0 1 2 1 2 4 4	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	1. 1. 1. 1.		000000000	000000000000000000000000000000000000000	000000000000000000000000000000000000000	0000000000	4 1 1 1 1 1 2	N N N N N N N N N N N N N N N N N N N	22222222222
.072 .53 .762 .53 .912 .53 1.037 .53 1.087 .53 1.167 .50 1.227 .50 1.302 .55 1.372 .50	1. 1. 1. 1. 1. 1.		0 0 0 0 0 0 0 1	000000000000000000000000000000000000000	000000000000000000000000000000000000000	000000000000000000000000000000000000000	2 4 1 1 1 1 3	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	22222222222
1.452 .55 0.000 0.00 .05548 .11550 .19050 .35050 .47047	1. 0.		000000000000000000000000000000000000000	0 0 0 0 0 0 10 0	000000000000000000000000000000000000000	00000400	) 1 1 1 2 3	1 2 0 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3	
44 .755 $46.925$ $461.095$ $461.240$ $461.410$ $431.575$ $461.745$ $461.745$ $461.915$ $46$	1. 1. 1. 1. 1. 1. 1.	000000000000000000000000000000000000000	000000000000000000000000000000000000000	000000000000000000000000000000000000000	000000000000000000000000000000000000000	000000000000000000000000000000000000000	4444444	* * * * * * * * * * * * * * * * * * *	22222222222 22222222222222222222222222
2.08044	2.	0	0	0	0	0	4	3 3	2

416 439 406 .5339 .54197.0.5556 .5556.5556.5556.5556.5556.5556.5
$\begin{array}{c} 2.365\\ 2.500\\ 2.725\\ 2.940\\ .050\\ .120\\ .200\\ .305\\ .405\\ .575\\ .760\\ .905\\ 1.085\\ 1.245\\ 1.245\\ 1.245\\ 1.245\\ 1.245\\ 1.245\\ 1.245\\ 1.245\\ 1.245\\ 1.245\\ 1.245\\ 1.245\\ 1.245\\ 1.245\\ 1.245\\ 1.245\\ 1.245\\ 1.245\\ 1.245\\ 1.245\\ 1.245\\ 1.245\\ 1.245\\ 1.245\\ 1.245\\ 1.283\\ 1.380\\ .600\\ .743\\ .900\\ 1.083\\ 1.174\\ 1.418\\ .092\\ .248\\ .429\\ .605\\ .756\\ .903\\ 1.044\\ \end{array}$
000000100000000000000000000000000000000
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0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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2141111214444334444444401111111111121444414444
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202 202 202 202 202 202 202 202 202 202

Age	Specific	Data	(continued)
)			(

210	1	4	0	0	0	0	0	1.426	569
210	1	1	0	0	10	3	0	1.593	<b></b> 531
210	1	3	0	0	0	0	6	1.674	538
210	1	1	2	0	0	0	0	1.754	545
210	1	1	0	0	0	0	Ú	1.875	<b></b> 555
210	1	3	0	0	Ú	Û	6	2.041	543
210	1	4	0	0	0	0	5	2.253	561
210	1	1	0	0	0	0	0	2.474	580
210	1	4	0	0	0	0	7	2.595	564
210	1	3	0	0	0	1	6	2.797	555
210	1	4	0	0	0	0	5	2.923	566
210	1	1	0	0	0	0	0	3.094	554
210	1	1	0	0	0	2	0	3.235	593
210	1	1	0	0	0	0	0	3.311	520
210		1	Ŭ	0	0	0	0	3.497	589
210	1	1	U	0	0	0	0	3.553	488
210	1	4	0	0	0	0	4	3.638	522
210	1	1	0	0	0	0	0	3.819	590
210	1	1	U	0	0	0	Ŭ	3.886	438
210	1	1	0	0	0	0	0	3.971	550
210	1	3	0	u o	כו	1	≺ ▲	•035	•545
210	1	4	0	0	0	0	1	.2/1	• 582
210	1	4	0	0	0	0	4	• 432	.510
210	1	4	0	0	0	0	3	.004	.521
210	1	44 31	0	0	0	0	1	• (50	• <b>5</b> 74
210	1	4	0	0	0	0	2	.941	•D[] E66
210	1	4	0	0	0	0	0	1.072	• 700
210	1	ו או	0	0	0	0	0	1.223	• 22 3
210	1	2	0	0	0	0	1	1.594	• 5,59 55/1
210	1	ر 1	0	0	0	0	0	1 722	- 562
210	1	2	0	0	0	0	1	2 050	- JUZ 508
210	1	2	0 0	0	ů Ú	0 0	2	2.059	526
210	1	 Ц	0	0	0	0	1	2.155	517
210	1	- Д	õ	õ	õ	ñ	1	2.201	- J17 504
210	1	-т Ц	0	õ	0	0	1	2 580	568
210	1	<u>ц</u>	õ	õ	õ	õ	1	2.775	.552
210	1	ג	ŏ	õ	õ	а Х	1	2.977	.588
210	1	<u>л</u>	õ	õ	õ	õ	1	3, 112	. 497
210	1	4	õ	õ	õ	õ	ג	3,269	.563
210	1	4	õ	õ	õ	õ	5	3,430	.523
210	1	4	ŭ	ŭ	õ	õ	2	3,601	.534
210	1	4	Õ	õ	õ	õ	6	3,772	.546
210	1	Ц	Õ	õ	õ	Õ	à	3,944	.531
210	1	1	õ	õ	õ	õ	õ	4,054	- 524
210	1	ג	õ	õ	õ	Õ	õ	4,296	517
210	1	ŭ	õ	õ	õ	Ō	õ	4,442	502
210	1	4	õ	Ō	ō	Ō	Õ	4,578	513
210	1	4	Ō	Ō	Ō	Ō	Ō	4.764	- 527
210	1	1	Ō	Ō	Ō	Ō	Ō	5.011	546
210	1	4	Ō	Ō	Ō	Ō	Ō	5.248	- 487
210	1	4	Ō	Ō	Ō	Ō	Ō	5.419	- 526

$\begin{array}{c}513\\476\\541\\ .520\\ .526\\ .512\\ .521\\ .5512\\ .5512\\ .5550\\55047\\5554749\\5555647\\5555647\\555566\\ .5555647\\555566\\ .55556\\ .55566\\ .55556\\ .55566\\ .55566\\ .5556\\ .5556\\ .5556\\ .5556\\ .5556\\ .5556\\ .5556\\ .5556\\ .5556\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5550\\ .5500\\ .5550\\ .5550\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\ .5500\\$
5.581 5.777 5.943 4.324 4.324 4.586 4.9841 5.575 5.943 4.324 4.5867 4.2473 5.9941 2450 1.228 1.228 1.228 1.228 2.317 2.306 1.2412 2.593 1.228 2.317 1.288 1.288 1.288 1.288 1.288 1.288 1.228 2.317 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 1.288 2.2995 1.2441 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949 2.2949
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215 215 215 215 215 215 215 215 215 215	222222222	4 4 4 4 4 3 3 2				000000000000000000000000000000000000000	1 0 0 7 5 9 22 40	.736 .922 1.033 1.259 1.420 1.606 1.787 1.857 2.043 2.254	506 515 524 507 515 499 456 460 496 481
215 215 215 215 215 215 215 215 215 215	<pre>&lt; 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2</pre>	4 4 2 4 4 2 4 4 4 4 4 4 4			0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0000300000	24 7 4 2 2 4 7 2 0 0 1	2.435 2.616 2.751 2.922 .109 .264 .420 .591 .762 .932 1.103	464 474 533 567 .592 .610 .593 .532 .549 .566
215 215 215 215 215 215 215 215 215 215	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	4 4 4 4 4 1 1 4	0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1 2 0	0 0 0 0 0 0 0 1 2 0	1 0 0 1 2 5 10 9	1.249 1.445 1.596 1.767 1.933 2.098 2.334 2.505 2.606 2.777	.559 .548 .541 .584 .575 .540 .528 .571 .592 .583
215 215 224 224 224 224 224 224 224 224 224 22	2 1 1 1 1 1 1 1	4 3 3 3 1 1 1	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0	0 0 0 1 0 0 0 0	1 2 6 3 14 7 0 0 0	2.928 2.928 1.116 1.221 1.317 1.477 1.563 1.643 1.719 1.814	.575 .575 481 497 492 502 507 512 490 522
224 224 224 224 224 224 224 224 224 224	1 1 1 1 1 1 1 1 1	4 1 2 4 4 4 4 4 4 4	0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0		000300000000000000000000000000000000000	0 0 17 0 0 0 0 0 13	1.935 2.080 2.211 2.307 2.432 2.603 2.759 2.935 3.101 3.261 3.452	475 459 466 472 506 490 525 509 519 529 540

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2211	1	3	0	Δ	0	0	6	2 569	517
224	4	2	ç	0	0	0		5.000	24/
224		3	U	0	0	0	11	3.643	551
224	1	3	0	0	0	0	9	3.729	556
224	1	3	0	0	0	0	ર	3 814	- 535
221	1	2	õ	õ	õ	Š	5	2 070	555
224	1	2	U	U	U	2	0	3.819	539
224	1	3	0	0	0	0	2	<b>3.9</b> 80	519
224	1	1	Ú	0	0	0	0	4, 141	- 475
224	1	1	0	0	Ô	Ô	Ō	1 212	- 528
221	4	4	õ	õ	õ	õ	0		) ) 0
224	I	1	0	U	U	0	U	4.417	518
224	1	1	0	0	0	0	0	4.477	522
224	1	1	0	0	0	0	0	4,558	- 553
224	1	1	Ō	Ō	Ō	Ň	õ	1 622	- 521
227	4	1	0	0	0	0	0		
224		4	U	0	U	0	0	4.774	513
224	1	4	0	0	0	0	0	4.925	548
224	1	1	0	0	0	0	2	1,121	.572
224	1	1	Ō	ñ	õ	Õ	ō	1 226	520
- <u>-</u>	4	4	0 0	0	0	0	° °	1.220	• 559
224	1	1	0	0	0	U	0	1.307	•501
224	1	1	0	0	0	4	1	1.402	.529
224	1	2	0	0	0	0	11	1,548	. 547
224	1	2	Õ	Ň	Ň	õ	1	1 628	5/12
224	4	2	õ	~	0	~	, ,	1.027	• )72
224		2	U	U	0	U	3	1. (04	• 504
224	1	4	0	0	0	0	0	1.910	.551
224	1	4	0	0	0	0	0	2.090	.541
224	1	Ц	0	Ň	0	Ō	й	2 256	584
221	4		0	0	0	0			- 504
224		4	U	0	0	0	U	2.417	•545
224	1	4	0	0	0	0	17	2.588	•538
224	1	3	0	0	0	0	14	2.729	.529
224	1	จั	0	0	0	0	10	2 804	551
2211	1	2	õ	õ	õ	2	12	2.001	• JJ1
224		2	0	0	0	5	12	2.009	.520
224	1	2	0	0	0	0	8	2.975	•541
224	1	2	0	0	0	0	12	3.075	•535
224	1	3	0	0	0	0	5	3, 151	.531
22/1	1	2	õ	õ	õ	õ	) )	2 221	526
227	4	2	0	Č	0	0		2.201	. 920
224	1	3	0	0	0	0	2	3.317	•521
224	1	1	0	0	0	0	0	3.397	•542
224	1	1	0	0	0	0	0	3,467	- 538
22/1	1	1	Ň	Ň	ō	õ	õ	2 552	522
227	4	4	0	Š	0	Š	0	J. J.J.J.	• 755
224	1	1	U	U	0	3	U	3.048	• 521
224	1	1	0	0	0	0	0	3.719	•523
224	1	1	0	0	0	0	2	3.809	.544
224	1	1	0	0	0	0	0	3 804	513
224	4	1	õ	õ	õ	õ	õ	2 075	E61
224			U	U	U	0	U	3.915	. 501
224	1	1	0	0	0	0	0	4.055	• 550
224	1	1	0	0	0	0	0	4.246	.518
224	1	1	0	0	0	0	0	4,472	.531
221	1	1	õ	õ	õ	õ	õ	1 559	552
224			0	~	0	0	0	4.000	• 223
224	1	1	U	U	U	U	U	4.804	•564
224	1	1	0	0	0	0	0	4.970	•554
224	1	4	0	0	0	0	6	5.064	- 565
2211	1	2	ñ	õ	õ	ñ	1	5 21/1	_ 575
224	1	2	~	Ň	0	0	1	5.214 E 001	
224	1	3	0	U	U	U	17	5.294	554
224	1	3	0	0	Ü	Û	7	5.384	561

Age	Spe	cific	Data	(cont	inued	)				
	224	1	2	0	0	0	6	2	5,539	518
	224	1	3	0	0	0	1	11	5.639	525
	224	1	2	0	0	0	0	6	5.714	531
	224	1	4	0	0	0	0	0	5.899	517
	224	1	1	Ú	0	0	0	0	6.034	500
	224	1	1	0	0	0	0	0	6.279	<b></b> 518
	224	1	1	0	0	0	0	0	6.439	556
	224	1	1	0	0	0	0	0	5.031	•531
	224	1	4	0	0	0	0	12	5.261	•541
	224 221	1	5	0	0	0	0	16	5.386	•533
	224 22/1	1	2	0	0	0	0	4	5.400	• 554
	224 221	1	2	0	0	0	0	20	5.551	•574
	224	1	Ц Ц	0	0	0	0	.)9 2	5.031	• 7 9 7
	224	1	4	õ	0	0	0	2	5.012	.200
	224	1	4	õ	õ	õ	õ	0	6 087	-00Z
	224	1	4	õ	õ	õ	õ	ŏ	6,232	. 606
	224	1	1	0	0	Ō	Õ	õ	6.357	.624
	224	1	1	0	0	0	Ō	Ō	6.452	.617
	244	1	1	0	0	O	0	0	.036	514
	244	1	1	C	0	0	C	2	. 126	515
	244	1	3	0	0	0	0	17	.201	516
	244	1	3	0	0	0	0	9	.301	490
	244	1	4	0	0	0	0	4	.411	491
	244	1	3	Û	0	0	0	13	•546	519
	244	1	4	0	0	0	0	3	•735	494
	244	1	2	0	2	0	0	6	.951	497
	244	1	4	0	0	0	0	3	1.070	525
	244 2)(),	1	4	0	0	0	0	22	1.240	521
	277 244	1	2	ő	0	0 G	ů N	22	1.401 1.5/i1	- 529
	244 244	1	2	2	<u>с</u>	6	0 0	2	1.541 1.646	- 558
	244	1	1	ō	õ	õ	ŭ	ר א	1.791	- 560
	244	1	1	Č	õ	õ	õ	õ	1.861	- 534
	244	1	1	Ō	Ō	Ō	Ō	Ō	1.956	535
	244	1	1	0	0	0	0	Ō	2.026	535
	244	1	4	0	0	0	0	0	2.226	538
	244	1	4	O	0	0	0	0	2.401	540
	244	1	2	Ũ	0	0	0	13	. 124	•566
	244	1	3	0	0	0	0	6	.204	.565
	244	1	4	0	0	0	0	17	. 409	.563
	244	1	3	0	0	0	0	10	.629	•585
	244	1	2	0	0	0	0	22	.714	•587
	244	1	2	0	0	0	0	10	• /89	.530
	244 2):).	1	20	U N	n N	U N	U n	19	• 227 のたみ	• 232 557
	こうう	1	2	D D	n	0	0	21	•904 1 〇山山	• 557 582
	277	1	1	2	ñ	n	n n	6	1 122	- 600
	244	1	1	0	õ	0 0	ñ	ñ	1.209	.582
	244	1	1	õ	õ	õ	õ	õ	1.295	.581
	244	1	1	Õ	Ō	Ō	Ō	õ	1.378	.607
	244	1	1	Ō	Ō	Ō	Ō	Ō	1.459	.579
	244	1	1	0	0	0	0	0	1.544	.578

244	1	3	0	0	0	2	17	1.674	•577
244	1	2	0	3	0	0	2	1.774	•575
244	1	5	0	0	0	0	12	1.859	•548
244	1	1	0	0	0	0	0	1.943	.001
244	1	-4 Ji	0	0	0	0	0	2.009	· 5/2
244	1	-4 Ji	0	0	0	0	0	2.239	• 597
277 211	C I	-	0	0	0 0	0	0	2.394	0.000
244 244	2	3	0	0	0	0	11	0.000	- 526
244	2	2	õ	0	õ	0	8	10Q	- 526
244	2	7	õ	0	0 0	õ	6	215	- 525
244	Ž	7	õ	õ	õ	õ	17	.472	500
244	2	ŭ	ũ	õ	õ	õ	14	.587	-, 579
244	ž	4	Õ	Õ	õ	õ	0	.743	500
244	2	4	0	Ō	Ō	Ō	Ō	.915	500
244	2	4	0	0	C	0	0	1.081	500
244	2	4	Û	0	0	0	0	1.237	474
244	2	4	0	0	0	0	0	1.403	447
244	2	4	0	0	0	0	Ũ	1.584	500
244	2	4	U	U	0	Û	0	1.755	474
244	2	1	0	U	0	Ũ	0	1.855	500
244	2	1	С	С	0	0	0	1.951	500
244	2	1	С	0	O	С	0	2.052	500
õпt	5	2	7	С	0	2	4	2.147	474
244	2	2	0	6	0	0	13	2.218	526
244	2	3	C	C	0	С	23	2.298	474
244	2	3	C .	0	C	Û	5	2.374	500
244	2	3	0	0	0	0	18	2.464	500
244	2	4	0	0	0	0	4	2.595	- 474
244	2	2	0	13	2	0	2	2. (20	4(4
244	2	3	0	0	0	0	12	2.000	-,4(4
244	2		0	0	0	0	21	2.907	4/4
244	2		0	0	0	0	2	2.095	- 500
244 211	2	1	0	0	0	0	0	2 285	- 171
244 266	2	1	0	0	ñ	0	0	3. 470	- 500
244	2	1	õ	0	õ	õ	2	3,541	- 473
244	2	ג	õ	õ	0	õ	12	3,637	- 474
244	Ž	3	õ	õ	õ	õ	22	3.803	- 447
244	2	1	õ	Ō	Ō	Õ	0	3.893	- 447
244	2	1	Ō	Ō	Ō	0	0	3.969	395
244	2	1	0	0	0	0	0	.037	.526
244	2	1	0	0	0	0	0	. 122	.526
244	2	1	Û	0	0	0	0	.223	•579
244	2	1	0	0	0	0	0	.298	•553
244	2	1	0	0	0	0	0	• 369	•553
244	2	1	U	U	0	0	0	. 464	•579
244	2	1	0	0	0	Û	0	.540	.605
244	2	1	0	0	0	0	0	.630	•553
244	2	1	0	0	0	0	0	.696	•579
244	5	1	0	0	0	0	0	•791	•579
244	2	1	0	0	0	0	0	.882	•553

Age	Specif	lic	Data	(cont:	inued)				
	244	2	1	0	0	0	0	0	<b>.973 .</b> 553
	244	2	4	0	0	0	0	0	1.093 .579
	244	2	4	0	0	0	0	0	1.259 .579
	244	2	4	O	0	0	0	2	1.390 .579
	244	2	4	0	0	0	0	0	1.566 .579
	244	2	4	0	0	0	0	0	1.752 .526
	244	2	4	0	0	0	0	0	1.938 .526
	244	2	2	0	0	0	0	37	2.145 .579
	244	2	2	0	0	0	0	13	2.215 .553
	244	2	3	U	Û	υ	Ŭ	4	2.381 .579
	244	2	3	0	0	0	0	3	2.462 .553
	244	2	3	0	0	0	0	16	2.547 .526
	244	2	3	0	0	0	0	24	<b>2.633</b> .553
	244	2	3	0	0	0	0	18	<b>2.723</b> .553
	244	2	3	0	0	0	0	7	<b>2.819</b> .553
	244	2	4	0	0	0	0	3	<b>2.945</b> .553
	244	2	4	0	0	0	0	0	3.076 .553
	244	2	4	0	0	0	0	0	3.257 .579
	244	2	3	0	0	0	0	16	3.398 .579
	244	2	2	0	0	17	8	2	3.468 .605
	244	2	2	10	υ	2	0	6	3.544 .605
	244	2	3	0	0	Û	0	4	3.644 .605
	244	2	3	0	0	0	0	18	<b>3.7</b> 20 <b>.</b> 579
	244	2	4	0	0	0	0	0	3.936 .605

### APPENDIX F

Ovipositional Behavior Data

The data is listed as i,j, k where i stands for bulb condition (l = rotting + infested 2 = rotting, 3 = normal), j stands for bulb type (l = large dry bulbs, 2 = large green bulbs, 3 = small green bulb.) and K equals the total number of immature onion maggots associated with each bulb.

CDDAONIONACT (5x,3F5.0)

## Ovipositional Behavior Data

i	j	k	i	i	k	j	i i	k
1	1	47	2	1	25	-	1	0
1	1	32	2	1	2		1	0
1	1	- Q	2	1	ā		2 1	Õ
1	1	53	2	1	2		) I	0
1	1	16	2	1	10		) 1	0
1	1	10	2	1	10			0
		20	2	1	12	1	3 1	0
1	1	30	2	1	0	3	5 1	Ŭ
1	1	28	2	1	9	3	3 1	0
1	1	33	2	1	7	(*)	1	0
1	1	50	2	1	21	3	1	0
1	1	27	2	1	4	3	3 1	0
1	1	20	2	1	20	-	1	0
1	1	39	2	1	0		1	0
1	1	2	2	1	10		1	0
1	1	<u>-</u> ኪ7	2	1	27	2	. 1	6
1	1	50	2	1	21		) I	0
1	1	1:6	2	1	17			0
1	1	40	2			1		ĺ
		55	2	1	<b>۲</b> ۶	-	1	U
1	2	43	2	2	6	3	2	0
1	2	5.1	2	2	21		2	0
1	2	25	2	2	13	3	2	3
1	2	23	2	2	2	3	2	0
1	2	58	2	2	9	3	2	0
1	2	16	2	2	0	3	2	0
1	2	17	2	2	10	-	2	0
1	2	28	2	2	11	2	2	0
1	2	26	2	2	10		2	Ō
1	2	21	2	2	14	1	2	Õ
1	2	32	2	2	<u>н</u>		2	õ
1	2	20	2	2	ġ		2	1
1	2	6	2	5	12			, ,
1	2	)ı 1	2	2	6			0
4	2		2	2	10			0
1	2	21	2	2				Û
	2	30	2	<	14		2	0
1	2	24	2	2	10	1	2	0
1	2	40	2	2	26	3	2	0
1	3	0	2	3	5		3	0
1	3	8	2	3	4	3	3	0
1	3	5	2	3	0	3	3	0
1	3	9	2	3	0	3	3	0
1	3	3	2	3	6	3	3	0
1	3	7	2	3	10	3	3	0
1	3	13	2	3	7	3	3	0
1	3	7	2	3	10		3	0
1	ŝ	15	2	3	2		3	3
1	จั	4	2	3	0	3	, र र	õ
1	วั	2	2	ĩ	7		, 7 7	Ō
1	2	Ц Ц	2	วั	ц		, 7 , 7	õ
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1	<u>כ</u>	10	20	ン 2	5		) ) )	7
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1	2	1	2	5	5	-	) J	0
1	5	۷	۷	5	4	•	s 5	U

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#### LITERATURE CITED

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