FIELD STUDIES COMPARING THE EFFECTIVENESS OF A SYNTHETIC FEMALE SEX PHEROMONE ([R,Z]-5-[1-DECENYL] DIHYDRO-2[3H]-FURANONE) AND A FLORAL BAIT (PHENYLETHYL PROPIONATE + EUGENOL 7:3) IN CONTROLLING ADULT POPULATIONS OF THE JAPANESE BEETLE (*POPILLIA JAPONICA* NEWMAN)

A Thesis

Presented to

the Faculty of the School of Sciences and Mathematics

Morehead State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

---

by

Sharon Kay Stahl

22 April 1981

Accepted by the faculty of the School of Sciences and Mathematics, Morehead State University, in partial fulfillment of the requirements for the Master of Science degree.

Gerald DeMoss
Director of Thesis

Master's Committee: Gerald DeMoss, Chairman

[signature]

Jerry F. Howell, Jr.

4-22-81
(date)

ABSTRACT OF THESIS

FIELD STUDIES COMPARING THE EFFECTIVENESS OF A SYNTHETIC FEMALE SEX PHEROMONE ([R,Z]-5-[1-DECENYL] DIHYDRO-2[3H]-FURANONE) AND A FLORAL BAIT (PHENYLETHYL PROPIONATE + EUGENOL 7:3) IN CONTROLLING ADULT POPULATIONS OF THE JAPANESE BEETLE (POPILLIA JAPONICA NEWMAN)

Popillia japonica Newman, the Japanese beetle, was first discovered in North America in 1916 near Riverton, New Jersey. The beetle has increased its range from 2.5 square miles in 1917 to approximately half of the United States in 1980. Japanese beetles, having little importance in their native Japan, are major pests of economically important agricultural and ornamental plants in both rural and urban areas of the U. S. Adult beetles actively feed on the foilage and fruit of various ornamentals, fruit trees and truck crops. Controls have been attempted to reduce beetle populations and to minimize their destruction but these attempts have all resulted in limited success.

Survey traps baited with floral attractants have been shown effective in reducing local beetle populations up to 30%. Phenylethyl propionate (PEP) + eugenol (7:3) is the most effective floral bait, when used in a standard Ellisco trap.

In 1977, a female sex pheromone was isolated and synthesized by researchers. Field tests conducted during the summer of 1980 were designed to determine the effectiveness of the commercial Integralure Bait System (sex pheromone plus floral bait) in reducing damage to preferred vegetation by adult populations.

Data obtained appear to support the concept of synergism, but did not support the claim of the manufacturer that the combined synthetic sex pheromone and floral lure was five times more effective in capturing adult P. japonica than the floral lure exposed singularly. Results showed that the combined lure was only 1.5 times more effective than the floral bait. It is possible that the increased effectiveness of the combined lure may have been caused by different methods of exposing the floral bait and not by a synergistic effect.

ACKNOWLEDGMENTS

I especially thank Dr. Gerald L. DeMoss, the chairman of my graduate committee, for his unending enthusiasm and guidance during the course of this research and my graduate study. I also thank Dr. Madison E. Pryor and Dr. Jerry F. Howell, Jr. for their advice and assistance in the preparation of the manuscript. I am grateful to Morehead State University for providing the facilities and assistantship which made this research possible.

Special thanks to Mrs. Dorothy Haney and Mr. Bill Haney for permitting field tests on their farms and for providing access to test plants. I also thank Dr. Gary C. Cox for the climatological data; Dr. T. L. Ladd, Jr. for providing me with published literature and samples of the synthetic sex pheromone; and Mr. J. Sidenberger and Baker Chemical Company for information regarding the Bag-A-Bug product.

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

The Japanese beetle, *Popillia japonica* Newman, an insect of little importance in its native Japan, is a major pest of agricultural and ornamental plants in both rural and urban areas of the United States. Adult and larval stages actively feed on more than three hundred species of vascular plants in North America (Fleming 1972).

Before *P. japonica* was first found in New Jersey in 1916, it was known to occur only on the main islands of the Japan Archipelago, with the greatest densities being restricted to the island of Hokkaido and to the northern half of Honshu. These areas are ecologically similar to the agricultural areas of the eastern United States, but the presence of natural enemies and the reduced geographical area occupied by grasslands help to keep populations under control in Japan (Clausen et al. 1927). In the eastern United States, favorable climate, absence of natural enemies, abundance of food, and large tracts of turf necessary for the development of the immature stages, facilitated the establishment of large and widespread populations of *P. japonica* (Fox 1927, 1932, 1934; Hawley and Dobbins 1945).

In 1917, one year after *P. japonica* had been discovered in New Jersey, the range of the beetle covered approximately 2.5 square miles (Smith and Hadley 1926); by 1970, it was estimated that populations inhabited 150,000 square miles in the United States (Fleming 1972). The present range of the beetle includes much of the United States east of the 100th meridian and scattered locations to the west. This line separates preferred soil types, essential amounts of rainfall, and the tolerated temperature extremes of the eastern United States from the physical factors that control the environment of the western United States. P. japonica has not been able to successfully invade the southern areas of the Gulf states or many areas of Canada because of temperature limitations (Fox 1939; Fleming 1972). An isolated population was eradicated in California in 1961 (Gammon 1961) and efforts were successful in eliminating the beetle from Nova Scotia between 1944 and 1953 (Fleming 1972). Gentry (1959) reported isolated colonies of P. japonica in Indiana, Kentucky, Missouri, Ohio Tennessee, Virginia, and West Virginia. His data showed that P. japonica first occupied portions of Kentucky in 1936.

Since 1916, attempts have been made to reduce P. japonica populations and to minimize their destruction. A control method commonly used in small local areas involves the capture of live Japanese beetles by attracting them to baited traps. It has been shown that floral attractants used in standard Japanese beetle traps are effective in reducing local beetle populations as much as thirty percent (Langford et al. 1940). Phenylethyl propionate (PEP) + eugenol (7:3) is the most effective floral lure when used in a standard Ellisco trap (McGovern et al. 1970). In 1977, a female sex pheromone was isolated and synthesized (Tumlinson et al. 1977). It is also commercially available for use as a bait to capture the adult beetle; however, no reports have been made concerning the value of the synthetic pheromone as a method of control.

Field tests used in this research were designed to determine the relative effectiveness of the synthetic sex pheromone in reducing damage to vegetation preferred by adult populations of *P. japonica*. The effectiveness of the floral bait (PEP + eugenol 7:3) was also tested. A commercial product which combines the components of both the synthetic sex pheromone and the floral bait was tested for effectiveness. It is possible that the commercial product produced synergism which, in turn, may have increased the number of adults captured.

LITERATURE REVIEW

Life History

Popillia japonica is a holometabolous insect. In North America, the life cycle is typically completed in one year; however, a two year life cycle has been reported in some northern locations (Fleming 1972). Clausen et al. (1927), while studying *P. japonica* in its native Japan, reported that two years were required for the development of the insect in the northern extremes of its range. They estimated that 75% of the beetles emerged in alternate years.

Adult *P. japonica* emerge in mid-June in the eastern United States (earlier in the south; later in the north). Morphologies of the male and female beetles have been described by Davis (1920), Hadley (1922), Smith and Hadley (1926) and Hadley and Hawley (1934). Adults usually live 35 to 40 days (Hadley and Hawley 1934). They attack a variety of vascular plants and cause extensive damage to preferred foods.

Larvae of *P. japonica* are soil forms which feed on the roots of various plants. Following oviposition and eclosion, grubs begin feeding in the upper ten centimeters of the soil. During this time, July through October, damage may be extensive to lawns and other large areas of turf. As soil temperatures decrease in the fall, the second or third larval instars, the overwintering stages, migrate to a depth of about twenty centimeters and become quiescent (Hawley 1944). Pupation occurs in the following spring.

Several environmental factors affect the metamorphosis of P. japonica. Susceptibility to dessication and the effects of temperature and relative humidities, were studied by Ludwig (1928, 1932, 1936) and Ludwig and Landsman (1937). Moist acidic soils (Polivka 1960), with temperatures ranging from about 17.5°C to 27.5°C (Fox 1939) are necessary for the developing immature stages. The overwintering stages are able to survive at lower temperatures, but not for prolonged periods. Shread (1944, 1945) reported that winter snow cover is beneficial in preventing extremely low, fatal temperatures. Fox (1939) suggested that less than ten inches of summer rainfall would be harmful to eggs and larvae. Hawley (1949) presented data indicating that populations of P. japonica were greatly reduced in years following summers in which less than ten inches of rain fell.

Reproduction

P. japonica females are considered promiscuous and will mate many times in their lives. Mating usually occurs on vegetation upon which the adults have been feeding. After mating occurs, females seek suitable sites for oviposition and eggs are generally deposited in or near wet, grassy fields where there is adequate food and moisture for proper development of the eggs and larval maturation. A female will enter the soil approximately sixteen times in her life, depositing one to five eggs each time. The total number of eggs laid by a female usually varies from forty to sixty (Smith and Hadley 1926; Hadley and Hawley 1934).

Feeding Habits

P. japonica larvae feed on the roots of many ornamental plants, agricultural crops, and various grasses. Feeding activity may cause extensive damage, sometimes killing the plants involved (Smith and Hadley 1926; Fleming 1963a). Damage to plants is often not detected until the injury is sufficient to reduce the vitality of the plant. The grubs are mobile, as demonstrated by Hawley (1935), and move horizontally through the soil in search of food.

Adult *P. japonica* have been observed feeding on the fruit and foilage of 395 species of vascular plants of which 47 are often extensively damaged (Fleming 1972).

Hawley and Metzger (1940) compiled the most comprehensive list of vegetation attacked by *P. japonica* (Fleming 1972).

The adult beetles are most active on sunny summer days, between 9 a.m. and 3 p.m., when the temperature is between 29°C and 35°C and the relative humidity is at least sixty percent. Little feeding occurs on cloudy days, and *P. japonica* are completely inactive when it rains (Smith 1923; Hawley and Metzger 1940).

Smith (1923), Smith and Hadley (1926), Hawley and Metzger (1940) and Fleming (1963a) have described the types of damage caused by adult *P. japonica*. Skeletonized foilage, partially consumed flower petals and orchard fruits, and the destruction of maturing corn silks are common examples of their voracious feeding habits.

A number of factors determine the vegetation on which *P. japonica* will feed. Adults are positively phototropic, as demonstrated by Moore and Cole (1921), and prefer vegetation exposed to the sun. Feeding usually begins near the top of the plant (Smith 1923; Fleming et al. 1934; Hawley and Metzger 1940). Smith and Hadley (1926), observing that *P. japonica* flew against the wind towards ripening fruit, suggested that the beetles were attracted by certain odors. Van Leeuwen et al. (1928) and Van Leeuwen (1932) have shown that P. japonica are gregarious and fifty percent more beetles will feed on vegetation already infested with P. japonica that on uninfested vegetation. Smith and Hadley (1926) suggested that the presence of females attracted many males to a plant.

Methods of Control

Because of its status as a pest, much of the work concerning P. japonica is in reference to methods of controlling adult and larval populations of the insect and their feeding habits. Control methods, including mechanical, biological and chemical controls, have neither significantly reduced populations nor prevented injury to preferred food plants, except in some local areas.

The methods of sterilizing male P. japonica, chemically and mechanically, and their effects on populations are discussed by Ladd (1966, 1968, 1970a, 1970b), Ladd et al. (1968) and Ladd et al. (1973a). Because of the promiscuous nature of P. japonica females, the release of sterile males would be successful only in isolated populations. Hand collecting adult P. japonica, as performed by Davis (1920), may reduce populations sufficiently to decrease the amount of damage to selected vegetation; however, this procedure is feasible only in small, lightly infested areas.

Biological controls. Much of the literature regarding the biological control of P. japonica concerns those parasitic and predaceous insects of foreign origin that attack grubs and adults of the genus Popillia. Native predators, such as birds and other insects, are not effective in reducing populations (Fleming 1969). Investigations of foreign parasites were conducted by Clausen and King (1924), Clausen et al. (1927, 1933) and Gardner and Parker (1940). As a result of their research, 26 species of parasitic and predaceous insects that feed on P. japonica were introduced into the United States; five became established. Only two of these, Tiphia popilliavora Rowher and Tiphia vernalis Rowher, have survived. These hymenopterans parasitize grubs of the genus Popillia and are, therefore, dependent on adequate larval populations of P. japonica for their survival, because the Japanese beetle is the only member of that genus found in North America (Fleming 1976). King (1931, 1937, 1939), King and Holloway (1930), King et al. (1951) and Smith and Hadley (1926) reported the colonization of these parasites.

Dutky (1940) described and named Bacillus lentimorbus Dutky and Bacillus popillae Dutky as two bacteria causing milky spore disease in P. japonica grubs. The biologies of the bacteria and their physiological effects on the grubs were studied by Dutky (1940), White (1940), White and Dutky (1940) and Beard (1944). A technique for the production, storage, and distribution of the milky disease spores, for use as a method of controlling grub populations, was patented by Dutky in 1941 and 1942. Information regarding the application of the spore dust was provided by Hadley (1948), Fleming (1961) and Ladd (1976).

Various nematodes (Glaser and Fox 1930; Glaser et al. 1942), fungal diseases (Smith and Hadley 1926; Hawley and White 1935), and other insects, particularly a robber fly (Asilidae) and a wheel-bug (Reduviidae) (Bromley 1945, 1946), are considered parasites of _P. japonica_, but are of little importance as controls.

Chemical controls. Inorganic and organic insecticides have been extensively used in attempts to control the feeding of larval and adult _P. japonica_. Applied as sprays, dusts, or fumigants, these substances can be successful in reducing injury to vegetation, but often have adverse effects on man and the environment.

A mixture of lead arsenate and sugar was, at one time, the most effective insecticide used against adult Japanese beetles (Smith 1930), but its injurious effects to particular vegetation limited the extent to which the insecticide was used (Fleming 1976). Lead arsenate has also been applied to soils and has been successful in decreasing larval populations. Applications were restricted to turf areas when Fleming et al. (1943) and McLean et al. (1944) reported the uptake of the insecticide by vegetable crops. Ethylene dichloride was effective in killing grubs in turf, but caused temporary injury to the grasses (Mason et al. 1943). Mason et al. (1945) showed that ethylene dibromide was as effective as ethylene dichloride in killing grubs, but ethylene dibromide did not damage turf. Annual early fall applications of these fumigants were necessary to destroy populations of second or third instar grubs before overwintering.

Rotenone and its derivatives, obtained from the roots of *Derris elliptica* and a species of *Lonchocarpus*, have low mammalian toxicity and were used for many years to control the feeding of adult *P. japonica*. Pyrethrum, obtained from the flowers of *Chrysanthemum cinerariaefolium*, has been used extensively as a contact spray to kill adult *P. japonica*, primarily in suburban areas (Van Leeuwen 1926; Van Leeuwen et al. 1928; Fleming 1933; Fleming and Metzger 1936, 1938; Hadley 1940). Constant reapplications of these insecticides were necessary because of their rapid decomposition when exposed to light (Cremlyn 1978).

The organochlorines and organophosphates are the most important groups of synthetic insecticides (Cremlyn 1978). Organochlorines were used as sprays (DDT) to kill adult P. japonica and as soil insecticides (DDT, dieldrin, aldrin, chlordane) to destroy grub populations. General use of these insecticides has been discontinued because of their high mammalian toxicity and rapid biological magnification. Fleming and Maines (1950) discussed the effectiveness of another organochlorine, methoxychlor, in killing adult P. japonica. Methoxychlor is less toxic to man, but not as efficient as DDT in protecting vegetation. Parathion, extremely hazardous to man, but effective in destroying adult P. japonica, and malathion, one of the least dangerous of all the insecticides, are biodegradable organophosphates that are not readily accumulated in the environment. These insecticides have been discussed by Fleming (1963b). Diazinon, a soil insecticide applied in late summer, was effective in killing a large percentage of P. japonica grubs (Fleming 1976).

Carbaryl, commonly known as Sevin, was the first commercial carbamate to be used successfully as a contact insecticide (Cremlyn 1978). According to Fleming (1976), carbaryl was not effective as a soil insecticide, but, as a spray, carbaryl killed many adult P. japonica (Fleming 1963b).

These insecticides are beneficial in that they reduce P. japonica populations and, therefore, reduce some of the damage they cause. But the necessity of constant reapplication, the potential threat to man and the environment, and the poisonous residues remaining on treated fruit and vegetables, may make some insecticides inefficient as controls.

Attractants. Chemical substances found attractive to P. japonica have been tested by many persons since 1919. Specific plants preferred by adults were analyzed and their common constituents were identified. These compounds were field tested singularly in traps, and in mixtures of varying proportions. As a result of these tests, technical geraniol, a complex mixture of geraniol, other alcohols, esters, and aldehydes, became the first commercial attractant used to capture adult P. japonica. Technical geraniol was patented in 1926 by Smith et al., with specifications by Metzger and Maines (1935). Originally a perfume, technical geraniol + eugenol (the major attractant in technical geraniol, Fleming 1969) was used to capture large numbers of P. japonica until 1944 (Fleming 1969). Fleming and Chisholm (1944) tested anethole (produced from domestic pine oil) + eugenol in a 9:1 mixture and found this combination to be superior to the geraniol-eugenol lure. The anethole-eugenol lure replaced the geraniol-eugenol lure and was used until 1965. Phenylethyl butyrate (PEB) + eugenol (9:1), similar in its effectiveness to the geraniol-eugenol (9:1) lure, became the primary attractant in 1966 (Schwartz et al. 1966, 1970). McGovern et al. (1970) considered phenylethyl propionate (PEP) + eugenol (7:3) to be the most attractive substance to date. According to Ladd et al. (1973c), the PEP-eugenol (7:3) lure was four to five times more attractive than the PEB-eugenol (9:1) lure. This attractant was patented in 1973 (McGovern et al. 1973), and is still considered the most attractive lure. The results of additional tests with PEP + eugenol have been contributed by Ladd et al. (1974), Ladd et al. (1976a) and Ladd et al. (1976b).

Numerous traps have been designed to capture adult P. japonica in conjunction with the testing of odiferous substances (Fleming 1969). The original bait can method was introduced by Brinley in 1923 (Fleming 1969). Improved changes in this method of capturing adult P. japonica, and testing the attractiveness of the isolated plant compounds, resulted in the development of a standard trap. Many changes, including structural modifications of the funnel and beetle receptacle, resulted in the production of the standard trap. Metzger (1928) recommended the addition of a four-winged baffle to the top of the funnel, and the resulting increase in beetle captures was verified by Langford et al. (1940). Alterations in funnel slope and aperature size were made by Metzger (1928). Because of the repellent nature of the odor produced by decomposing P. *japonica*, Rex (1931, 1932) designed a wire receptacle to replace the original glass jar used to capture beetles. Langford et al. (1940) made further improvements on the beetle receptacle. The standard Ellisco trap, presently used to capture adult beetles, was designed by Schwartz et al. (1966). Klein et al. (1973b, 1973c) suggested shielding the funnel of the standard Ellisco trap and replacing the perforated bait well with plastic overlapping cones. These changes were not adopted because of the additional costs involved.

Trap colors have also been subjected to changes. Richmond and Metzger (1929) reported that traps painted with medium chrome green captured more P. *japonica* than unpainted traps; Van Leeuwen and Metzger (1930) showed that 45% more beetles could be captured in green traps. A yellow trap was suggested by Fleming et al. (1940), and was used from 1940 through 1967 (Fleming 1976). Traps with a green beetle receptacle and a yellow bait well were used in the design of the standard Ellisco trap (Schwartz et al. 1966).

A survey trap, similar to the original bait-can trap, was patented by Armstrong and Metzger in 1935. Because the purpose of the survey trap was to record the presence or absence of *P. japonica* beyond known areas of infestation, a beetle receptacle smaller than the one used in the standard Ellisco trap was used (Fleming 1969). Over the years, the survey trap has undergone changes similar to those of the standard trap.

The effectiveness of traps in capturing adult *P. japonica* and in preventing or reducing damage to vegetation has been reported by a number of researchers. Preferred food plants are more attractive to the beetle than baited traps, and more beetles were captured in traps placed near preferred vegetation than in traps placed farther away from preferred food (Fleming 1976). Field tests conducted by Langford et al. (1939) showed that grub populations were reduced in areas where traps had been placed. Landford et al. (1940) estimated that one baited trap per acre captured about thirty percent of the local adult population. Fleming et al. (1940) reported that about 75% of *P. japonica*, attracted to a baited trap, were captured and, although damage to vegetation was still extensive, the traps aided in reducing the degree of damage.

Sex attraction. The presence of a volatile sex pheromone was suggested by Smith and Hadley (1926) when they observed that male *P. japonica* flew close to the ground in search of emerging females. This attraction was confirmed by Ladd (1970c) and Goonewardene et al. (1970). Klein et al. (1972a) reported that traps baited with virgin females beetles were more than twenty times as attractive to males as were traps baited with the PEP-eugenol lure. Klein et al. (1973a) presented data suggesting that simultaneous exposure of unmated female *P. japonica* and the PEP-eugenol lure did not significantly increase the total number of *P. japonica* captured over those captured by traps baited with virgin female beetles alone. Other studies involving the exposure of virgin females, as lures in traps, were made by Klein et al. (1972b) and Ladd et al. (1973b). The pheromone, produced in the abdomen (Fleming 1970), was isolated, identified, and synthesized ([R,Z]-5-[1-Decenyl] dihydro-2[3H]-furanone) in 1977 (Tumlinson et al. 1977).

MATERIALS AND METHODS

Field tests to determine the attractiveness to Japanese beetles of (R,Z)-5-(1-Decenyl) dihydro-2 (3H)-furanone, a synthetic sex pheromone, singularly and in combination with the PEP-eugenol (7:3) lure, were conducted during the summer of 1980. The two lures were exposed in traps designed to capture *Popillia japonica*. PEP + eugenol (floral lure) was exposed in the bait wells of Ellisco traps; the combined pheromone (sex lure) and floral lure were exposed as prepared strips on Bag-A-Bug traps. Unbaited Ellisco traps were used as controls to demonstrate the minimal attraction of *P. japonica* to the traps. The traps were suspended 44 inches (1.1m) above the ground on steel rods placed thirty feet (9.1m) apart. The test area, located in Rowan County, Kentucky, consisted of cultivated farmland along the Middle Fork of Big Brushy Creek. Baited traps were placed 25 feet (7.6m) downwind of four plants highly preferred as food by *P. japonica*. According to Fleming (1972), apple (*Malus sylvestris*), multiflora rose (*Rosa multiflora*), sassafras (*Sassafras albidum*), and grape (*Vitis* sp.), experience extensive feeding by *P. japonica*. The use of these plants, in orchards and along fencerows, insured adequate and relatively equal amounts of feeding activity. Baited traps placed in an open field were used as controls.

The Ellisco traps and granular PEP-eugenol bait were obtained from commercial sources. Bag-A-Bug traps, with the Integralure Bait System (sex lure strips and floral lure strips exposed on the same trap), were also purchased commercially. Dr. T. L. Ladd, Jr. of the Japanese Beetle Research Laboratory in Wooster, Ohio, provided the synthetic sex pheromone other than that purchased as part of the Bag-A-Bug product.

Fresh granular bait was added to the Ellisco traps after 17 days of trapping and again after 33 days of trapping according to instructions received with the product. The floral lure strips, used in the Integralure Bait System, were changed after 33 days when the fruit odor was no longer apparent. The sex lure strips remained on the traps for the duration of the test period. Plastic bags, used to confine captured *P. japonica* in the Bag-A-Bug traps, were replaced after a rain, when the beetles filled the bag during a single test day, and when the odor of decomposing beetles was considered to be severe enough to act as a potential repellent.

Adult beetles were collected for a period of seven weeks beginning with the time of their emergence on 20

June 1980. Collections were made daily with the exception of two weeks in July after the population density had peaked. Traps were emptied in the early evening when most of the daily activity had ceased. Specimans trapped were preserved in seventy percent ETOH and returned to the laboratory for the purpose of determining sex and establishing numerical counts. Morphological differences in the foretibial spurs and tarsal segments were used to separate the sexes. Dead specimans were disposed of promptly after being sexed and counted.

The effectiveness of the bait composed of the sex pheromone and floral lure was determined by counting and comparing numbers of _P. japonica_ captured in baited traps placed near four preferred vegetation types, by observing the amount of damage incurred during the peak period of feeding activity, and by comparing the results with similar data obtained for the floral lure (PEP-eugenol). A Chi square (x^2) statistical test was used to determine differences between the two trapping techniques.

Daily temperatures and relative humidities were monitored and general climatic conditions were observed and recorded. These records aided in establishing correlations between the weather and the numbers of _P._

japonica captured which, in turn, were indicative of the amount of activity. Observations were made each week to determine vegetative damage; photographs were taken to record the damage.

RESULTS AND DISCUSSION

Total numbers of Popillia japonica captured during the 35 day test period, are listed in Appendix A. The data are arranged according to; (1) trap day; (2) type of vegetation being protected (A=apple, G=grape, S=sassafras, R=rose, C=control); (3) type of bait used in the trap (I=sex lure, II=combined sex lure and floral lure, III=floral lure, IV=unbaited); and (4) sex of the captured beetles. Total weekly captures according to bait types are listed in Table 1. In Table 2, the total weekly captures are arranged according to the type of vegetation being protected. Total captures during the test period for trap types II and III, are listed in Table 3.

Initial collections, when beetle activity was first observed, were small, but captures increased rapidly as the population densities became greater. Population densities peaked during the fourth week of collecting and gradually declined in numbers until October. Collections were discontinued after 7 August 1980 when a significant decline in captured beetles suggested that the local population had attained maximum density and feeding activity was decreasing.

Weather conditions were optimal for the feeding

Table 1. Total Weekly Captures of Adult *Popillia japonica* Arranged According to the Individual Types of Traps Tested.

	Trap I		Trap II		Trap III		Trap IV	
	Male	Female	Male	Female	Male	Female	Male	Female
Week 1 6/20-6/26	318	30	674	195	116	121	75	18
Week 2 6/27-7/03	418	73	5090	2588	1146	1043	94	49
Week 3 7/04-7/10	611	132	30216	18966	16154	15692	101	94
Week 4 7/11-7/17	558	163	63084	47767	42542	42627	9741*	9336*
Week 5 8/01-8/07	396	92	40608	33177	20653	20477	8051*	6722*
Subtotals	2301	490	139672	102693	80611	79960	18062	16219
Totals	2791		242365		160571		34281	

*Includes control trap baited with only the floral lure strip for comparison with the Integralure Bait System.

Table 2. A Comparison of Total Weekly Captures of Adult *Popillia japonica* Arranged According to Preferred Vegetation Types.

	Malus sylvestris		*Vitis* sp.		*Sassafras albidum*		*Rosa multiflora*		Control	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Week 1 6/20-6/26	266	72	136	52	87	38	403	69	291	133
Week 2 6/27-7/03	1646	920	886	457	909	407	1331	593	1976	1376
Week 3 7/04-7/10	9780	7250	4358	3324	9243	6018	13449	8629	10252	9663
Week 4 7/11-7/17	18315	16050	16229	13495	25953	20961	31799	28068	23629	21319
Week 5 8/01-8/07	11015	8899	11321	11269	12675	10909	16127	13897	18570	15494
Subtotals	41022	33191	32930	28597	48867	38333	63109	51256	54718	47985
Totals	74213		61527		87200		114365		102703	

Table 3. Total Captures of Adult *Popillia japonica* Arranged for Traps II and III.

	Trap II	Trap III
Males	139672	80611
Females	102693	79960
Totals	242365	160571

Table 4. Captured Adult *Popillia japonica* in Test Traps Set Near *Rosa multiflora*.

	Males	Females	Totals
R-I	750	102	852
R-II	33998	23328	57326
R-III	28201	27731	55932
R-IV	160	95	255
Totals	63109	51256	114365

activity of adult P. japonica during the summer of 1980. Most days were sunny, hot, and humid, with noon temperatures ranging from 18°C to 36°C. The mean noon temperature during the test period was 29.79°C. A drought during the summer and fall of 1980 may have affected the activity and maturation of the larval stages by reducing soil moisture. A minimum of ten inches of summer rainfall is required for eclosion and the development of P. japonica larvae to the second and third instar stages, the overwintering forms. Total rainfall during the test period was approximately 6.2". Normal rainfall for eastern Kentucky during the same time period is approximately 8.2". The lack of adequate moisture in the soil during the summer and fall of 1980 should result in decreased densities of local Japanese beetle populations in 1981.

Vegetation Damage

Visual observations of damage to preferred vegetation by the feeding activity of adult P. japonica were based on the amount of defoliation in relation to the size of the plant when protected by a specifically baited trap. Late spring frosts destroyed most of the apple and grape flowers and some of the test plants did not bear fruit. No damage to existing fruit was observed.

Observations of the vegetation revealed that, although a total of 440,008 Japanese beetles were captured, preferred vegetation was still damaged. Most of the vegetation was only moderately damaged, but the injuries were sufficient to decrease the vitality of the plant.

Of the four preferred foods employed in this research, multiflora rose (Rosa multiflora) was the most heavily damaged. Approximately fifty percent of each of the four test plants were defoliated. Total beetle captures in three baited traps and one unbaited trap placed near rose plants are shown in Table 4 and these data exceed captures from similarly baited traps near other vegetation types. Traps placed near multiflora rose plants captured 114,365 adult P. japonica in the 35 collection days. Trap R-II captured 57,326 beetles, of which 59% were males. Beetles collected in trap R-III totalled 55,932. Approximately fifty percent of these beetles were males. Trap R-I and trap R-IV captured 852 beetles and 255 beetles, respectively. During the first week of testing, multiflora rose traps captured 472 beetles and approximately 85% of these beetles were males (Table 2). The percentage of captured males decreased in the succeeding weeks. Approximately 69% of the beetles captured during week two were males and sixty percent of the beetles collected during the third week were males. The percentage of males continued to decrease through week four but captured males increased slightly from week four, 53.1% males, to week five, 53.7% males.

It appears as though the amount of damage to protected rose plants may have been caused by increased beetle activity in response to the placement of highly attractive baited traps in close proximity to the plants. Test plants near traps R-II and R-III were more defoliated than the control plant near R-IV. Fleming (1976) stated that preferred food plants were more highly attractive to adult P. japonica than baited traps and that traps near preferred foods captured more beetles than traps away from preferred vegetation. A comparison of the total numbers of beetles captured near rose plants (114,365) to the total number of beetles captured in control traps (102,703) suggests that traps placed away from preferred food attract and capture large numbers of beetles without the potential risk of damage to valuable plants.

Damage to the foilage of grape plants (Vitis sp.) was moderate to severe. Adults fed most heavily on the foilage of small grape vines protected by traps G-I and G-IV, completely defoliating these plants. Trap G-I captured 397 beetles and trap G-IV captured 108 beetles.

Collections from trap G-II totalled 42,682 beetles and trap G-III captured 18,340 beetles (Table 5). Damage to these plants was restricted to the upper foilage. Collections from the four grape traps totalled 61,527, the lowest number of beetles captured near a particular type of vegetation. Male beetles represented 53% of the total number collected from these traps. Weekly percentages of males gradually decreased from 72% in the first week of fifty percent in week five.

Apple foilage was only moderately injured with some defoliation of the upper leaves of the trees. Test trees of Malus sylvestris were of the dwarf and semi-dwarf varieties. Trap A-I captured 324 beetles and trap A-IV collected 117 beetles. Apple trees with traps A-I and A-IV placed near them were not defoliated, but a cherry tree within twenty feet of trap A-I was severely injured, with approximately 100% defoliation. The proximity of trap A-I to the cherry tree and the fact that the trap was not positioned downwind of this plant, may have contributed to the damage. Little damage was observed to apple trees protected by traps A-II and A-III, which captured 50,761 beetles and 23,011 beetles, respectively (Table 6). A total of 74,213 beetles were captured in apple traps; 55% were males. The weekly percentages of males decreased from 78% in the first week to 55% in the

Table 5. Captured Adult *Popillia japonica* in Test Traps Set Near *Vitis* sp.

	Males	Females	Totals
G-I	311	86	397
G-II	23723	18959	42682
G-III	8826	9514	18340
G-IV	70	38	108
Totals	32930	28597	61527

Table 6. Captured Adult *Popillia japonica* in Test Traps Set Near *Malus sylvestris*.

	Males	Females	Totals
A-I	245	79	324
A-II	29053	21708	50761
A-III	11672	11339	23011
A-IV	52	65	117
Totals	41022	33191	74213

final week of collecting.

Sassafras plants (Sassafras albidum) were the least damaged of the preferred vegetation types tested with little defoliation. Sassafras traps captured 87,200 beetles. The test plant at which trap S-III was placed was the most damaged with approximately forty percent defoliation and trap S-III collected 40,107 beetles (Table 7). Trap S-I captured 554 beetles, of which 89% were males. Trap S-IV collected a total of 73 beetles. Approximately 59% of the 46,466 beetles captured in trap S-II, were males. Of the beetles collected from sassafras traps during week one and week two, 69% were males. Sixty percent of those captured in the third week were males. Captured males represented 55% and 54% of the totals in the final two weeks of collecting.

Traps used as controls were placed in an open field and provided valuable data for this research. According to Fleming (1976) and instructions received with the Ellisco traps and the Bag-A-Bug traps, the proximity of the trap with respect to the vegetation being protected was important. Each trap was positioned downwind of a preferred food plant in an effort to intercept adult beetles as they approached the vegetation; however, the control traps, placed in an area without preferred foods, captured more beetles than similarly baited traps placed

Table 7. Captured Adult *Popillia japonica* in Test Traps Set Near *Sassafras albidum*.

	Males	Females	Totals
S-I	493	61	554
S-II	27366	19100	46466
S-III	20956	19151	40107
S-IV	52	21	73
Totals	48867	38333	87200

Table 8. Captured Adult *Popillia japonica* in Control Traps.

	Males	Females	Totals
C-I	502	162	664
C-II	25532	19598	45130
C-III	10956	12225	23181
C-IV	17728*	16000*	33728*
Totals	54718	47985	102703

*Includes control trap baited with only the floral lure strip for comparison with the Integralure Bait System.

near apple, grape, or sassafras plants. Control traps, including a Bag-A-Bug trap with only the floral lure strip added for ten collection days, captured 102,703 beetles. Males represented 53% of the total. Collections from traps C-II and C-III were 45,130 and 23,181, respectively (Table 8). These data represent collections at two of the most active traps throughout the test period. Trap C-IV was changed from an unbaited canister trap to a trap with a floral bait strip during the last two weeks of the research and in ten days collected 33,657 beetles. These data indicate that the baited traps were as attractive to the beetles as were some preferred foods. Furthermore, these data suggest that baited traps do not serve only as interceptors for beetles moving to preferred foods but that baited traps attract large numbers of P. japonica, and positioning the baited traps near preferred vegetation may not be necessary if beetle capture is the primary objective when using baited traps. Baited traps may actually attract more Japanese beetles to the vicinity of food plants, increasing the risk of damage to those plants.

Trap Effectiveness

The effectiveness of baited traps in capturing adult P. japonica was determined by counting the numbers of beetles collected in specifically baited traps placed near preferred vegetation and applying statistical analyses to the numbers obtained.

A total of 440,008 adult P. japonica were captured in 20 traps during the 35 day test period. A small number of beetles, primarily males, were collected from trap type I (sex lure). Collections from these traps totalled 2,791 beetles; 2,301 male beetles and 490 female beetles. According to Klein et al. (1972), virgin female beetles were more than twenty times as attractive to male beetles as the floral lure, PEP + eugenol (7:3). Trap type III, baited with the floral lure, captured 80,611 male beetles, approximately 35 times more male beetles than trap type I, baited with the synthetic sex lure. These data suggest that the synthetic sex lure was not as attractive as virgin female beetles and the sex lure was not the primary attractant when combined with the floral lure as in the Integralure Bait System of trap type II. Weekly percentages of captured males always exceeded 75% in trap type I, but the percentage of males did decrease as the test period progressed. Most of the sexual activity of the adult Japanese beetle occurs during the first few weeks, after the initial appearance of the beetles, when many virgin females may be found. The decline in percentages of captured male beetles may be attributed to a decrease in the sexual activity of the beetles.

The purpose of the unbaited traps (trap type IV) was to demonstrate the attractiveness or lack of attractiveness of the trap itself to adult _P. japonica_. The unbaited traps captured 624 beetles, a small, insignificant number of the local adult population and the data reflect the minimal attraction of the beetles to the traps. Data for trap type IV in Table 1, from weeks four and five are noticeably higher than in previous weeks. On 14 July, Day 25 of collecting, the unbaited control trap (C-IV) was replaced with a Bag-A-Bug trap with only the floral lure strip of the Integralure Bait System. This trap was baited with the same lure as trap III but differed in the method of exposure. The purpose of changing the trap was to determine conclusively that the floral lure strip of the Integralure Bait System was the more attractive unit of the bait for Bag-A-Bug traps. This trap, in a period of ten days, captured 33,657 beetles. During the same ten day period, trap C-III collected 32,873 beetles and trap C-II baited with the floral lure and sex lure captured 21,882 beetles. The data presented in Appendix A for trap C-IV for the ten day period, supports the idea that the floral lure strip was more attractive to adult beetles than the sex lure strip. A comparison of trap

C-III and the added control trap baited with the floral lure strip, suggest that the method of exposure of the floral lure strip of the Integralure Bait System is superior to that of the granular floral bait in the Ellisco trap. It is possible that increased captures in trap type II may have resulted from the superior method of exposure of the floral lure in the Integralure Bait System and not from a synergistic effect.

Traps II and III were the only traps that captured statistically significant amounts of adult P. japonica. Total captures for these traps are listed in Table 3. Trap type III captured 160,571 beetles, of which fifty percent were males. These data indicate that the floral lure has equal attractiveness to both male and female P. japonica. Approximately 58% of the 242,365 beetles collected from trap type II were males. These data show increased male activity at traps baited with the Integralure Bait System and support the concept of increased collections resulting from a synergistic effect of the two baits when placed together. These two traps captured 92% of the total number of beetles collected during the test period. Trap type II captured a significantly greater number of beetles (x^2 test; 1 d.f.; $P<0.05$) than did trap type III; however, data obtained in this research does not support the claim of the manufacturer of the Bag-A-Bug trap that the Integralure Bait System captures up to five times as many beetles as any other trap. A proportional inference test at the 0.05 level of significance was used to check this claim. Data from field tests show the attractiveness of the Integralure Bait System as used in trap type II, to be approximately 1.5 times that of the granular floral bait used in trap type III. This increase may reflect a synergistic effect resulting from the simultaneous exposure of the two lures, or it may have been caused by the different methods of exposing the floral attractants. Further study is necessary to determine the actual cause for the increased captures in trap type II.

Trap type III captured approximately fifty percent males throughout the test period. The increased attractiveness to males of the added sex lure strip in trap type II, resulted in higher percentages of captured males, but the ratio of males to females became more even as the season progressed and the sexual activity of the beetles declined.

It is necessary to note that both trapping techniques have some mechanical inconveniences. Beetles captured in the receptacles of Ellisco traps must be disposed of in a separate container. Bag-A-Bug traps employ plastic, disposable bags as beetle receptacles and, when full, are discarded and replaced. The Bag-A-Bug product is supplied with three (retail) or six (mail-order) replaceable bags, an insufficient number when trapping beetles in heavily infested areas. Because they are lightweight and blow easily in the wind, these plastic bags often become twisted near the top of the bag restricting the entry of beetles into the bag. Moisture, causing the sides of the bag to adhere together, may also restrict the capture of beetles.

Traps baited with floral attractants capture up to thirty percent of the local adult population of P. japonica (Langford et al. 1940). Bag-A-Bug traps are described as five times more effective than any other beetle trap. If baited traps actually capture thirty percent of the local adult population, then, the statement by Bag-A-Bug manufacturers suggests that their product captures up to 150% of the local adult population. The data presented in this study indicates that Bag-A-Bug traps capture 1.5 times more beetles, approximately thirty to forty-five percent of the local adult population of P. japonica.

Because most of the traps captured large numbers of P. japonica and reduced the population size, it was assumed that baited traps did afford some protection to the plants, but, when used alone, baited traps were not sufficient in preventing damage to preferred vegetation. When integrated with other control methods, primarily insecticides, baited traps may provide additional protection to preferred foods and may be instrumental in reducing the local densities of succeeding generations of *P. japonica*.

SUMMARY

Field tests were conducted during the summer of 1980 to determine the effectiveness of synthetic female sex pheromone and a floral attractant in controlling adult populations of _Popillia japonica_ and reducing damage to preferred vegetation.

A total of 440,008 adult Japanese beetles were captured in twenty traps during the 35 day test period. Four traps placed near apple trees collected 74,213 beetles. Traps near grape vines captured 61,527 adult beetles. A total of 87,200 beetles were collected from sassafras traps and traps protecting multiflora rose plants captured 114,365 adult Japanese beetles, the largest number of beetles captured near a preferred food. Multiflora rose was the most seriously damaged of the four preferred food types. Control traps captured 102,703 adult _P. japonica_.

Traps baited with the synthetic sex pheromone (trap type I) and unbaited traps (trap type IV) collected a small percentage of the total number of beetles captured during the study. Trap type III, baited with the floral attractant and trap type II, baited with the combined sex lure and floral lure captured 92% of the total number of trapped adult _P. japonica_. Trap type III captured

57 times more beetles than trap type I and trap type II collected 1.5 times more beetles than trap type III.

Observations of the vegetation involved in this study revealed that baited traps did not prevent damage, but the numerical data suggested that baited traps did reduce the amount of damage. Numerical data showed that traps baited with the floral lure or the combined floral lure and synthetic sex pheromone attracted and captured large numbers of adult beetles; the combined lure captured significantly greater numbers of beetles. The increased attractiveness of the combined lure may be attributed to synergism produced by the simultaneous exposure of the two lures. Data also suggested that the method of exposure of the floral lure may have resulted in the capture of larger numbers of P. japonica.

Baited traps are of little value in protecting vegetation when used alone. It is necessary to integrate this method of control with other types of control to provide total protection to valuable vegetation.

LITERATURE CITED

Beard, R. L. 1944. Susceptibility of Japanese beetle larvae to Bacillus popilliae. J. Econ. Ent. 37:702-708.

Bromley, S. W. 1945. Robber fly and Japanese beetle. Brooklyn Ent. Soc. Bull. 40:44-47.

Bromley, S. W. 1946. Wheel-bug vs. Japanese beetle. Ent. News 7:21.

Clausen, C. P., H. A. Jaynes, and T. R. Gardner. 1933. Further investigations of parasites of Popillia japonica in the far east. U. S. Dept. Agr. Tech. Bull. 366. 58p.

Clausen, C. P., and J. L. King. 1924. A preliminary report on the foreign parasites of Popillia japonica. J. Econ. Ent. 17:76-79.

Clausen, C. P., J. L. King, and C. Teranishi. 1927. The parasites of Popillia japonica in Japan and Chosen (Korea), and their introduction into the United States. U. S. Dept. Agr. Bull. 1429. 56p.

Cremlyn, R. 1978. Pesticides: Preparation and Mode of Action. John Wiley and Sons, Ltd. New York:New York. 216p.

Davis, J. J. 1920. The green Japanese beetle. N. J. Dept. Agr. Circ. 30. 33p.

Dutky, S. R. 1940. Two new spore-forming bacteria causing milky disease of Japanese beetle larvae. J. Agr. Res. 61:57-68.

Fleming, W. E. 1933. Contact sprays for the Japanese beetle. U. S. Dept. Agr. Circ. 280. 4p.

Fleming, W. E. 1961. Milky disease for control of Japanese beetle grubs. U. S. Dept. Agr. Leafl. 500. 6p.

Fleming, W. E. 1963a. The Japanese beetle in the United States. U. S. Dept. Agr. Handb. 236. 30p.

Fleming, W. E. 1963b. The Japanese beetle: how to control it. U. S. Dept. Agr. Farmer's Bull. 2151. 16p. (rev.).

Fleming, W. E. 1969. Attractants for the Japanese beetle. U. S. Dept. Agr. Tech. Bull. 1399. 87p.

Fleming, W. E. 1972. Biology of the Japanese beetle. U. S. Dept. Agr. Tech. Bull. 1449. 129p.

Fleming, W. E. 1976. Integrating control of the Japanese beetle--a historical review. U. S. Dept. Agr. Tech. Bull. 1545. 64p.

Fleming, W. E., F. E. Baker, and L. Koblitsky. 1943. Effect of lead arsenate in the soil on vegetables. J. Econ. Ent. 36:231-233.

Fleming, W. E., E. D. Burgess, and W. W. Maines. 1940. The use of traps against the Japanese beetle. U. S. Dept. Agr. Circ. 594. 12p.

Fleming, W. E., and R. D. Chisholm. 1944. Anethole and pimenta leaf oil as attractants for the Japanese beetle. J. Econ. Ent. 37:116.

Fleming, W. E., and W. W. Maines. 1950. Effectiveness of methoxychlor against the Japanese beetle. U. S. Dept. Agr., Bur. Ent. and Plant Quar. E-797. 4p.

Fleming, W. E., and F. W. Metzger. 1936. Control of the Japanese beetle on fruit and shade trees. U. S. Dept. Agr. Circ. 237. 12p. (rev.).

Fleming, W. E., and F. W. Metzger. 1938. Control of the Japanese beetle and its grub in home and garden. U. S. Dept. Agr. Circ. 401. 15p. (rev.).

Fleming, W. E., F. W. Metzger, and M. R. Osburn. 1934. Protection of orchard and shade trees and ornamental shrubs from injury by the Japanese beetle. U. S. Dept. Agr. Circ. 317. 8p.

Fox, H. 1927. The present range of the Japanese beetle, *Popillia japonica* Newm., in America and some factors influencing its spread. J. Econ. Ent. 20:383-391.

Fox, H. 1932. The known distribution of the Japanese beetle in 1930 and 1931, with special reference to the areas of continuous distribution. J. Econ. Ent. 25:396-407.

Fox, H. 1934. The known distribution of the Japanese beetle in 1932 and 1933. J. Econ. Ent. 27:461-473.

Fox, H. 1939. The probable future distribution of the Japanese beetle in North America. N. Y. Ent. Soc. J. 67(2):105-123.

Gammon, E. T. 1961. The Japanese beetle in Sacramento. California Dept. Agr. Bull. 50:221-235.

Gardner, T. R., and L. B. Parker. 1940. Investigations of the parasites of *Popillia japonica* and related Scarabaeidae in the far east from 1929 to 1933, inclusive. U. S. Dept. Agr. Tech. Bull. 738. 36p.

Gentry, J. W. 1959. Japanese beetle appraisal survey in outlying areas, 1958. J. Econ. Ent. 52:771-772.

Glaser, R. W., and H. Fox. 1930. A nematode parasite of the Japanese beetle, *Popillia japonica* Newm. Science 71:16-17.

Glaser, R. W., E. E. McCoy, and H. B. Girth. 1942. The biology and culture of *Neoaplectana chresima*, a nematode parasite in insects. J. Parasitol. 28:123-126.

Goonewardene, H. F., D. B. Zepp, and A. E. Grosvenor. 1970. Virgin female Japanese beetles as lures in field traps. J. Econ. Ent. 63:1001-1003.

Hadley, C. H. 1922. The Japanese beetle. N. J. Dept. Agr. Circ. 46. 20p.

Hadley, C. H. 1940. The Japanese beetle and its control. U. S. Dept. Agr. Farmer's Bull. 1856. 22p.

Hadley, C. H. 1948. Milky disease for control of Japanese beetle grubs. U. S. Dept. Agr., Bur. Ent. and Plant Quar. EC-4. 8p.

Hadley, C. H., and I. M. Hawley. 1934. General information about the Japanese beetle in the United States. U. S. Dept. Agr. Circ. 332. 23p.

Hawley, I. M. 1935. Horizontal movement of larvae of the Japanese beetle in field plots. J. Econ. Ent. 28:656.

Hawley, I. M. 1944. Notes on the biology of the Japanese beetle. U. S. Bur. Ent. and Plant Quar. E-615. 18p.

Hawley, I. M. 1949. The effect of summer rainfall on Japanese beetle populations. N. Y. Ent. Soc. J. 57:167-176.

Hawley, I. M., and T. N. Dobbins. 1945. The distribution and abundance of the Japanese beetle from 1935 through 1943 with a discussion of some of the known factors that influence its behavior. N. Y. Ent. Soc. J. 53:1-20.

Hawley, I. M., and F. W. Metzger. 1940. Feeding habits of the adult Japanese beetle. U. S. Dept. Agr. Circ. 547. 31p.

Hawley, I. M., and G. F. White. 1935. Preliminary studies of the diseases of larvae of the Japanese beetle (Popillia japonica Newm.). N. Y. Ent. Soc. J. 43:405-412.

King, J. L. 1931. The present status of the established parasites of Popillia japonica Newman. J. Econ. Ent. 24:435-462.

King, J. L. 1937. Liberations of Japanese beetle parasites in the eastern states in 1937. U. S. Dept. Agr. Insect Pest Survey Bull. 17 pp. 473-483.

King, J. L. 1939. Colonization of Japanese beetle parasites in the eastern states in 1938. U. S. Dept. Agr. Insect Pest Survey Bull. 19, sup. to No. 1 pp.25-28.

King, J. L., and J. K. Holloway. 1930. The establishment and colonization of Tiphia popilliavora, a parasite of the Japanese beetle. J. Econ. Ent. 23:266-274.

King, J. L., L. B. Parker, and H. J. Willard. 1951. Status of important parasites of the Japanese beetle in 1950. U. S. Dept. Agr. Insect Pest Survey Spec. Sup. 5. 18p.

Klein, M. G., T. L. Ladd, Jr., and K. O. Lawrence. 1972a. A field comparison of lure for Japanese beetles: unmated females vs. phenylethyl propionate + eugenol (7:3). Env. Ent. 1(4):397-399.

Klein, M. G., T. L. Ladd, Jr., and K. O. Lawrence. 1972b. The influence of height of exposure of virgin female Japanese beetles on captures of males. Env. Ent. 1:600-601.

Klein, M. G., T. L. Ladd, Jr., and K. O. Lawrence. 1973a. Simultaneous exposure of phenylethyl propionate + eugenol (7:3) and virgin female Japanese beetles as a lure. J. Econ. Ent. 66:373-374.

Klein, M. G., K. O. Lawrence, and T. L. Ladd, Jr. 1973b. A modified trap for the Japanese beetle. J. Econ. Ent. 66:275-276.

Klein, M. G., K. O. Lawrence, and T. L. Ladd, Jr. 1973c. Japanese beetles: shielded traps to increase captures. J. Econ. Ent. 66:562-563.

Ladd, T. L., Jr. 1966. Egg viability and longevity of Japanese beetles treated with tepa, apholate, and metepa. J. Econ. Ent. 59:422-425.

Ladd, T. L., Jr. 1968. The permanent and cumulative effect of tepa-induced sterility in male Japanese beetles. J. Econ. Ent. 61:1058-1059.

Ladd, T. L., Jr. 1970a. Mating competitiveness of male Japanese beetles sterilized with tepa. J. Econ. Ent. 63:438-439.

Ladd, T. L., Jr. 1970b. Screening of candidate chemosterilants against the Japanese beetle. J. Econ. Ent. 63:458-460.

Ladd, T. L., Jr. 1970c. Sex attraction in the Japanese beetle. J. Econ. Ent. 63:905-908.

Ladd, T. L., Jr. 1976. Controlling the Japanese beetle. U. S. Dept. of Agr. Home and Garden Bull. 159. 15p.

Ladd, T. L., Jr., C. R. Buriff, M. Beroza, and T. P. McGovern. 1976a. Japanese beetles: attractancy of mixtures of lures containing phenylethyl propionate and eugenol. J. Econ. Ent. 68:819-120.

Ladd, T. L., Jr., R. T. Canfield, and A. J. Forgash. 1973a. Sterilization of Japanese beetles by gamma radiation. J. Econ. Ent. 66:1047-1048.

Ladd, T. L., Jr., C. W. Collier, and E. L. Plasket. 1968. Mass sterilization of Japanese beetles with tepa and the determination of residues. J. Econ. Ent. 61:942-944.

Ladd, T. L., Jr., M. G. Klein, and K. O. Lawrence. 1973b. Japanese beetles: attractive females as lures in colored traps. J. Econ. Ent. 66:1236-1237.

Ladd, T. L., Jr., M. G. Klein, K. O. Lawrence, and M. Beroza. 1974. Japanese beetles: duration of attractancy in the field of phenylethyl propionate plus eugenol. J. Econ. Ent. 67:139-140.

Ladd, T. L., Jr., T. P. McGovern, M. Beroza, C. R. Buriff, and M. G. Klein. 1976b. Japanese beetles: attractancy of phenylethyl propionate + eugenol (7:3) and synthetic eugenol. J. Econ. Ent. 69:468-470.

Ladd, T. L., Jr., T. P. McGovern, M. Beroza, B. G. Townshend, M. G. Klein, and K. O. Lawrence. 1973c. Japanese beetles: phenylethyl esters as attractants. J. Econ. Ent. 66:369-370.

Langford, G. S., S. L. Crosthwait, and F. B. Whittington. 1939. A review of cooperative Japanese beetle retardation work in Maryland. J. Econ. Ent. 32:255-259.

Langford, G. S., S. L. Crosthwait, and F. B. Whittington. 1940. The value of traps in Japanese beetle control. J. Econ. Ent. 33:317-320.

Ludwig, D. 1928. The effects of temperature on the development of an insect (Popillia japonica Newman). Physiol. Zool. 1:358-389.

Ludwig, D. 1932. The effect of temperature on the growth curves of the Japanese beetle (Popillia japonica Newman). Physiol. Zool. 5:431-447.

Ludwig, D. 1936. The effect of dessication on survival and metamorphosis of the Japanese beetle (Popillia japonica Newman). Physiol. Zool. 9:27-42.

Ludwig, D., and H. M. Landsman. 1937. The effect of different relative humidities on survival and metamorphosis of the Japanese beetle (Popillia japonica Newman). Physiol. Zool. 10:171-179.

Mason, A. C., and R. D. Chisholm. 1945. Ethylene dibromide as a fumigant for the Japanese beetle. J. Econ. Ent. 38:717-718.

Mason, A. C., R. D. Chisholm, and E. D. Burgess. 1943. Ethylene dichloride treatments for the immature stages of the Japanese beetle. J. Econ. Ent. 36:734-737.

McLean, H. C., A. L. Weber, and J. S. Jaffe. 1944. Arsenic content of vegetables grown in soils treated with lead arsenate. J. Econ. Ent. 37:315-316.

McGovern, T. P., M. Beroza, T. L. Ladd, Jr., J. C. Ingangi, and J. P. Jurimas. 1970. Phenylethyl propionate, a potent new attractant for Japanese beetles. J. Econ. Ent. 63:1727-1729.

McGovern, T. P., T. L. Ladd, Jr., M. Beroza, R. Sarmiento, M. G. Klein, and K. O. Lawrence. 1973. Attraction of Japanese beetles by chemicals related to phenethyl propionate (plus eugenol) and effect of selected additives. J. Econ. Ent. 66:1103-1105.

Metzger, F. W. 1928. Information concerning Japanese beetle traps. N. J. Dept. Agr. Circ. 146. 8p.

Metzger, F. W., and W. W. Maines. 1935. Relation between the physical properties and chemical components of various grades of geraniol and their attractiveness to the Japanese beetle. U. S. Dept. Agr. Tech. Bull. 501. 14p.

Moore, A. R., and W. H. Cole. 1921. The response of *Popillia japonica* to light and the Weberfechner law. *J. Gen. Physiol.* 3:331-335.

Polivka, J. B. 1960. Effect of lime applications to soil on Japanese beetle larval populations. *J. Econ. Ent.* 53:476-477.

Rex, E. G. 1931. A wire beetle receptacle for Japanese beetle traps. *N. Y. Ent. Soc. J.* 39:593-594.

Rex, E. G. 1932. Instructions for the maintenance of Japanese beetle traps. N. J. Dept. Agr. Circ. 222. 16p.

Richmond, E. A., and F. W. Metzger. 1929. A trap for the Japanese beetle. *J. Econ. Ent.* 22:299-310.

Schread, J. C. 1944. Japanese beetle. Conn. Agr. Expt. Sta. Bull. 481. pp 264-267.

Schread, J. C. 1945. Japanese beetle. Conn. Agr. Expt. Sta. Bull. 488. pp 331-339.

Schwartz, P. H., D. W. Hamilton, C. W. Jester, and B. G. Townshend. 1966. Attractants for Japanese beetles tested in the field. *J. Econ. Ent.* 59:1516-1517.

Schwartz, P. H., D. W. Hamilton, and B. G. Townshend. 1970. Mixtures of compounds as lures for the Japanese beetle. *J. Econ. Ent.* 63:41-43.

Sidenberger, J. 1981. Verbal communication; J. T. Baker Chemical Company. Phillipsburg, N. J., April 13, 1981.

Smith, L. B. 1923. Feeding habits of the Japanese beetle which influence its control. U. S. Dept. Agr. Bull. 1154. 12p.

Smith, L. B. 1930. The Japanese beetle in 1929. *J. Econ. Ent.* 23:495-501.

Smith, L. B., and C. H. Hadley. 1926. The Japanese beetle. U. S. Dept. Agr. Circ. 363. 67p.

Tumlinson, J. H., M. G. Klein, R. E. Doolittle, T. L. Ladd, Jr., and A. T. Proveaux. 1977. Identification of the female Japanese beetle sex pheromone: inhibition of male response by an enantiomer. Science 197:789-792.

Van Leeuwen, E. R. 1926. A contact spray for the Japanese beetle (Popillia japonica Newman). J. Econ. Ent. 19:786-790.

Van Leeuwen, E. R. 1932. Reactions of the Japanese beetle to spray deposits on foilage. U. S. Dept. Agr. Circ. 227. 19p.

Van Leeuwen, E. R., O. G. Anderson, and P. A. Vander Meulen. 1928. Some phases of Japanese beetle investigations. J. Econ. Ent. 21:805-813.

Van Leeuwen, E. R., and F. W. Metzger. 1930. Traps for the Japanese beetle. U. S. Dept. Agr. Circ. 130. 16p.

White, R. T. 1940. Survival of type A milky disease of Japanese beetle under adverse field conditions. J. Econ. Ent. 33:303-306.

White, R. T., and S. R. Dutky. 1940. Effect of the introduction of milky disease on populations of Japanese beetle larvae. J. Econ. Ent. 33:306-308.

APPENDIX A

FRIDAY 20 JUNE DAY 1

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	2		2	100
A-II				
A-III				
A-IV				
G-I	1		1	100
G-II				
G-III	3	1	4	75
G-IV	2		2	100
S-I				
S-II	1		1	100
S-III				
S-IV				
R-I	17	1	18	94
R-II		1	1	0
R-III				
R-IV	3	1	4	75
C-I		1	1	0
C-II	8	1	9	89
C-III	2	3	5	40
C-IV	1		1	100
TOTALS	40	9	49	82

SATURDAY 21 JUNE DAY 2

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	2		2	100
A-II	4	4	8	50
A-III				
A-IV				
G-I				
G-II	3		3	100
G-III	2	1	3	67
G-IV		1	1	0
S-I				
S-II		1	1	0
S-III				
S-IV				
R-I	13	2	15	87
R-II		1	1	0
R-III	1		1	100
R-IV	2	1	3	67
C-I	1		1	100
C-II	8	3	11	73
C-III	1		1	100
C-IV				
TOTALS	37	14	51	73

SUNDAY 22 JUNE DAY 3

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	3		3	100
A-II	17	5	22	77
A-III	1	2	3	33
A-IV				
G-I	1		1	100
G-II	1	1	2	50
G-III		3	3	0
G-IV	3		3	100
S-I				
S-II	2		2	100
S-III		2	2	0
S-IV				
R-I	9	1	10	90
R-II	2		2	100
R-III	3		3	100
R-IV		1	1	0
C-I	1		1	100
C-II	19	10	29	66
C-III	1	5	6	17
C-IV				
TOTALS	63	30	93	68

MONDAY 23 JUNE DAY 4

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	3		3	100
A-II	16	5	21	76
A-III				
A-IV				
G-I	3		3	100
G-II	4	1	5	80
G-III		2	2	0
G-IV		1	1	0
S-I				
S-II	2	1	3	67
S-III		1	1	0
S-IV				
R-I	16	4	20	80
R-II	5	5	10	50
R-III	3		3	100
R-IV	3		3	100
C-I		1	1	0
C-II	54	6	60	90
C-III	2	8	10	20
C-IV				
TOTALS	111	35	146	76

TUESDAY 24 JUNE DAY 5

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I				
A-II		1	1	0
A-III		1	1	0
A-IV				
G-I				
G-II				
G-III				
G-IV				
S-I				
S-II				
S-III				
S-IV	1	1	2	50
R-I	6		6	100
R-II	1		1	100
R-III				
R-IV	2		2	100
C-I	1		1	100
C-II	2		2	100
C-III				
C-IV				
TOTALS	13	3	16	81

WEDNESDAY 25 JUNE DAY 6

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I				
A-II	91	10	101	90
A-III	3	4	7	43
A-IV	1		1	100
G-I	10		10	100
G-II	9	4	13	69
G-III	4	2	6	67
G-IV	5	2	7	71
S-I	1		1	100
S-II	22	2	24	92
S-III	5	3	8	63
S-IV				
R-I	143	4	147	97
R-II	16	8	24	67
R-III	5	5	10	50
R-IV	26	4	30	87
C-I	9	1	10	90
C-II	51	8	59	86
C-III	9	11	20	45
C-IV	2		2	100
TOTALS	412	68	480	86

THURSDAY 26 JUNE DAY 7

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	1		1	100
A-II	116	32	148	78
A-III	6	8	14	43
A-IV				
G-I	16	5	21	76
G-II	44	15	59	75
G-III	15	12	27	56
G-IV	10	1	11	91
S-I	1	1	2	50
S-II	38	14	52	73
S-III	14	12	26	54
S-IV				
R-I	53	6	59	90
R-II	34	12	46	74
R-III	26	8	34	77
R-IV	14	4	18	78
C-I	5	3	8	63
C-II	104	44	148	70
C-III	10	27	37	27
C-IV		1	1	0
TOTALS	507	205	712	71

FRIDAY 27 JUNE DAY 8

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I				
A-II	72	37	109	66
A-III	8	3	11	73
A-IV				
G-I	13	2	15	87
G-II	65	22	87	75
G-III	8	5	13	62
G-IV	2	1	3	67
S-I				
S-II	25	12	37	68
S-III	20	7	27	74
S-IV				
R-I	38	8	46	83
R-II	42	16	58	72
R-III	15	17	32	47
R-IV	10	2	12	83
C-I	5	2	7	71
C-II	172	93	265	65
C-III	20	21	41	49
C-IV	1	1	2	50
TOTALS	516	249	765	68

SATURDAY 28 JUNE DAY 9

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	5	3	8	63
A-II	160	59	219	73
A-III	18	15	33	55
A-IV	10	4	14	71
G-I	2	1	3	67
G-II	83	21	104	80
G-III	17	15	32	53
G-IV				
S-I				
S-II	47	10	57	83
S-III	18	11	29	62
S-IV				
R-I	31	5	36	86
R-II	22	5	27	82
R-III	25	14	39	64
R-IV	6	5	11	55
C-I	12	5	17	71
C-II	271	147	418	65
C-III	25	33	58	43
C-IV	1		1	100
TOTALS	753	353	1106	68

SUNDAY 29 JUNE DAY 10

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	1	1	2	50
A-II	17	8	25	68
A-III	3	4	7	43
A-IV				
G-I	13	2	15	87
G-II	23	3	26	89
G-III	3	2	5	60
G-IV	5	5	10	50
S-I				
S-II	6		6	100
S-III				
S-IV				
R-I	73	9	82	89
R-II	6	3	9	67
R-III		2	2	0
R-IV	8	2	10	80
C-I				
C-II	75	25	100	75
C-III	3	17	20	15
C-IV	1		1	100
TOTALS	237	83	320	74

MONDAY 30 JUNE DAY 11

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	2		2	100
A-II	119	41	160	74
A-III	28	22	50	56
A-IV				
G-I	10		10	100
G-II	77	24	101	76
G-III	14	4	18	78
G-IV	4	3	7	57
S-I	1		1	100
S-II	35	7	42	83
S-III	9	7	16	56
S-IV				
R-I	61	1	62	98
R-II	17	4	21	81
R-III	8	2	10	80
R-IV	17	8	25	68
C-I	14	3	17	82
C-II	126	53	179	70
C-III	19	25	44	43
C-IV	2		2	100
TOTALS	563	204	767	73

TUESDAY 1 JULY DAY 12

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	1		1	100
A-II	497	243	740	67
A-III	49	70	119	41
A-IV		1	1	0
G-I	19	2	21	91
G-II	144	85	229	63
G-III	43	39	82	52
G-IV	1	1	2	50
S-I	2		2	100
S-II	206	82	288	72
S-III	122	65	187	65
S-IV				
R-I	57	6	63	91
R-II	370	196	566	65
R-III	116	57	173	67
R-IV	4	4	8	50
C-I	13	2	15	87
C-II	310	178	488	64
C-III	104	148	252	41
C-IV	2	3	5	40
TOTALS	2060	1182	3242	64

WEDNESDAY 2 JULY DAY 13

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I				
A-II	454	289	743	61
A-III	64	56	120	53
A-IV	1		1	100
G-I	8	2	10	80
G-II	190	111	301	63
G-III	66	61	127	52
G-IV		4	4	0
S-I				
S-II	328	147	475	69
S-III	62	52	114	54
S-IV				
R-I	6	2	8	75
R-II	243	161	404	60
R-III	61	34	95	64
R-IV	4	2	6	67
C-I	9	6	15	60
C-II	481	358	839	57
C-III	118	145	263	45
C-IV	4	1	5	80
TOTALS	2099	1431	3530	60

THURSDAY 3 JULY DAY 14

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I				
A-II	118	37	155	76
A-III	17	26	43	40
A-IV	2	1	3	67
G-I	4	2	6	67
G-II	56	30	86	65
G-III	11	10	21	52
G-IV	5		5	100
S-I	5		5	100
S-II	16	3	19	84
S-III	7	4	11	64
S-IV				
R-I	7	4	11	64
R-II	76	16	92	83
R-III	5	8	13	39
R-IV	3		3	100
C-I	6	5	11	55
C-II	141	62	203	70
C-III	40	42	82	49
C-IV	1	1	2	50
TOTALS	520	251	771	67

FRIDAY 4 JULY DAY 15

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	3		3	100
A-II	305	125	430	71
A-III	12	19	31	39
A-IV	3	1	4	75
G-I	5	1	6	83
G-II	86	44	130	66
G-III	20	12	32	63
G-IV	2	1	3	67
S-I	2		2	100
S-II	112	20	132	85
S-III	13	8	21	62
S-IV				
R-I	19	4	23	83
R-II	213	51	264	81
R-III	17	6	23	74
R-IV	5		5	100
C-I	8	3	11	73
C-II	169	106	275	62
C-III	47	77	124	38
C-IV	3	1	4	75
TOTALS	1044	479	1523	69

SATURDAY 5 JULY DAY 16

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	11		11	100
A-II	673	175	848	79
A-III	96	63	159	60
A-IV	5	5	10	50
G-I	32	2	34	94
G-II	406	160	566	72
G-III	75	40	115	65
G-IV	11	2	13	85
S-I	19	1	20	95
S-II	509	145	654	78
S-III	91	45	136	67
S-IV	1		1	100
R-I	26		26	100
R-II	814	174	988	82
R-III	65	28	93	70
R-IV	1	2	3	33
C-I	15	3	18	83
C-II	1221	442	1663	73
C-III	179	240	419	43
C-IV	4	2	6	67
TOTALS	4254	1529	5783	74

SUNDAY 6 JULY DAY 17

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	43	15	58	74
A-II	875	741	1616	54
A-III	207	238	445	47
A-IV	3	8	11	27
G-I	15	6	21	71
G-II	512	283	795	64
G-III	162	225	387	42
G-IV		2	2	0
S-I	20	4	24	83
S-II	972	599	1571	62
S-III	225	216	441	51
S-IV		1	1	0
R-I	31	4	35	89
R-II	765	585	1350	57
R-III	117	117	234	50
R-IV	6	4	10	60
C-I	25	8	33	76
C-II	883	1248	2131	41
C-III	260	468	728	36
C-IV	2	3	5	40
TOTALS	5123	4775	9898	52

MONDAY 7 JULY DAY 18

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	20	14	34	59
A-II	933	905	1838	51
A-III	474	589	1063	45
A-IV	6	8	14	43
G-I	8	4	12	67
G-II	355	223	578	61
G-III	437	642	1079	41
G-IV	2	2	4	50
S-I	28	4	32	88
S-II	890	733	1623	55
S-III	816	671	1487	55
S-IV	1		1	100
R-I	7	2	9	78
R-II	1272	978	2250	57
R-III	653	545	1198	55
R-IV	8	9	17	47
C-I	26	10	36	72
C-II	792	804	1596	50
C-III	471	718	1189	40
C-IV	5	4	9	56
TOTALS	7204	6865	14069	51

TUESDAY 8 JULY DAY 19

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	6	3	9	67
A-II	960	712	1672	57
A-III	332	409	741	45
A-IV	4	6	10	40
G-I	17	5	22	77
G-II	668	417	1085	62
G-III	236	310	546	43
G-IV	2	1	3	67
S-I	21		21	100
S-II	661	456	1117	59
S-III	604	560	1164	52
S-IV		1	1	0
R-I	2	1	3	67
R-II	1275	661	1936	66
R-III	908	834	1742	52
R-IV	3	5	8	38
C-I	20	11	31	65
C-II	1295	1188	2483	52
C-III	498	749	1247	40
C-IV		3	3	0
TOTALS	7512	6332	13844	54

WEDNESDAY 9 JULY DAY 20

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	18	4	22	82
A-II	1647	1083	2730	60
A-III	686	556	1242	55
A-IV	4	4	8	50
G-I	8	2	10	80
G-II	333	121	454	73
G-III	429	362	791	54
G-IV	3	2	5	60
S-I	27	3	30	90
S-II	1217	449	1666	73
S-III	1227	741	1968	62
S-IV		1	1	0
R-I	9	1	10	90
R-II	1470	659	2129	69
R-III	1687	1115	2802	60
R-IV	4	4	8	50
C-I	43	7	50	86
C-II	1739	1066	2805	62
C-III	721	656	1377	52
C-IV	5	2	7	71
TOTALS	11277	6838	18115	62

THURSDAY 10 JULY DAY 21

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	14	2	16	88
A-II	1500	671	2171	69
A-III	938	891	1829	51
A-IV	2	3	5	40
G-I	15	4	19	79
G-II	227	116	343	66
G-III	291	335	626	47
G-IV	1		1	100
S-I	16	1	17	94
S-II	778	362	1140	68
S-III	993	996	1989	50
S-IV		1	1	0
R-I	14	2	16	88
R-II	2361	1042	3403	69
R-III	1692	1794	3486	49
R-IV	5	2	7	71
C-I	18	1	19	95
C-II	1328	1422	2750	48
C-III	475	427	892	53
C-IV		4	4	0
TOTALS	10668	8066	18734	60

FRIDAY 11 JULY DAY 22

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	22	11	33	67
A-II	1239	884	2123	58
A-III	1335	1281	2616	51
A-IV	3	3	6	50
G-I	13	2	15	87
G-II	501	155	656	76
G-III	699	730	1429	49
G-IV	3	1	4	75
S-I	1	1	2	50
S-II	846	430	1276	66
S-III	1922	1266	3188	60
S-IV	34	3	37	92
R-I	11	2	13	85
R-II	2607	1212	3819	68
R-III	2228	1626	3854	58
R-IV	2	4	6	33
C-I	32	14	46	70
C-II	1636	1277	2913	56
C-III	986	1022	2008	49
C-IV	1	2	3	33
TOTALS	14121	9926	24047	59

SATURDAY 12 JULY DAY 23

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	10	10	20	50
A-II	1740	1306	3046	57
A-III	486	569	1055	46
A-IV	1	2	3	33
G-I	4	3	7	57
G-II	843	639	1482	57
G-III	500	517	1017	49
G-IV		3	3	0
S-I	22	6	28	79
S-II	1753	1014	2767	63
S-III	1801	1592	3393	53
S-IV				
R-I	6	2	8	75
R-II	2315	1379	3694	63
R-III	1951	1894	3845	51
R-IV	3	7	10	30
C-I	8	7	15	53
C-II	691	640	1331	52
C-III	597	712	1309	46
C-IV	1	2	3	33
TOTALS	12732	10304	23036	55

SUNDAY 13 JULY DAY 24

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I				
A-II	1784	1340	3124	57
A-III	618	737	1355	46
A-IV	1	3	4	25
G-I	7	8	15	47
G-II	2001	1194	3195	63
G-III	1101	1245	2346	47
G-IV				
S-I	16	3	19	84
S-II	2189	1676	3865	57
S-III	1477	1337	2814	53
S-IV	2		2	100
R-I	15	6	21	71
R-II	1736	1291	3027	57
R-III	1950	1766	3716	53
R-IV	4	5	9	44
C-I	14	1	15	93
C-II	807	542	1349	60
C-III	669	633	1302	51
C-IV	1	2	3	33
TOTALS	14392	11789	26181	55

MONDAY 14 JULY DAY 25

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	1	1	2	50
A-II	1928	1507	3435	56
A-III	816	751	1567	52
A-IV		3	3	0
G-I	2	1	3	67
G-II	1658	1133	2791	59
G-III	927	1087	2014	46
G-IV		1	1	0
S-I	14	6	20	70
S-II	2396	1813	4209	57
S-III	2205	1807	4012	55
S-IV	4	1	5	80
R-I	11	2	13	85
R-II	3107	2063	5170	60
R-III	2709	2686	5395	50
R-IV		6	6	0
C-I	7	4	11	64
C-II	636	506	1142	56
C-III	383	373	756	51
C-IV	1	1	2	50
TOTALS	16805	13752	30557	55

TUESDAY 15 JULY DAY 26

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	4		4	100
A-II	2160	1620	3780	57
A-III	498	539	1037	48
A-IV		2	2	0
G-I	4	1	5	80
G-II	1523	1401	2924	52
G-III	583	623	1206	48
G-IV				
S-I	22	6	28	79
S-II	1731	1369	3100	56
S-III	1621	1533	3154	51
S-IV	1	2	3	33
R-I	12	5	17	71
R-II	2656	2034	4690	57
R-III	2278	2658	4936	46
R-IV	4	1	5	80
C-I	16	12	28	57
C-II	2892	1851	4743	61
C-III	908	1082	1990	46
C-IV	2880	2950	5830	49
TOTALS	19793	17689	37482	53

WEDNESDAY 16 JULY DAY 27

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	4	2	6	67
A-II	1746	2790	4536	39
A-III	482	542	1024	47
A-IV		1	1	0
G-I				
G-II	1724	1180	2904	59
G-III	414	523	937	44
G-IV	9	3	12	75
S-I	47	9	56	84
S-II	1987	1522	3509	57
S-III	1527	1807	3334	46
S-IV		1	1	0
R-I	9	3	12	75
R-II	1596	2843	4439	36
R-III	2368	2947	5315	45
R-IV	2	3	5	40
C-I	24	11	35	69
C-II	854	540	1394	61
C-III	637	745	1382	46
C-IV	2504	2271	4775	52
TOTALS	15934	17743	33677	47

THURSDAY 17 JULY DAY 28

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	34	4	38	90
A-II	2450	1319	3769	65
A-III	951	819	1770	54
A-IV	2	4	6	33
G-I	20	3	23	87
G-II	3046	2277	5323	57
G-III	647	764	1411	46
G-IV		1	1	0
S-I	97	2	99	98
S-II	2924	2381	5305	55
S-III	1309	1370	2679	49
S-IV	5	4	9	56
R-I	11	1	12	92
R-II	2281	1690	3971	57
R-III	1927	1932	3859	50
R-IV				
C-I	38	14	52	73
C-II	1101	949	2050	54
C-III	1032	1112	2144	48
C-IV	4273	4044	8317	51
TOTALS	22148	18690	40838	54

FRIDAY 1 AUGUST DAY 43

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	2	2	4	50
A-II	1586	1163	2749	58
A-III	848	750	1598	53
A-IV	2		2	100
G-I	10	2	12	83
G-II	1826	1839	3665	50
G-III	400	375	775	52
G-IV				
S-I	16	1	17	94
S-II	2118	1569	3687	58
S-III	1392	1247	2639	53
S-IV				
R-I	5	2	7	71
R-II	1552	1272	2824	55
R-III	1990	1964	3954	50
R-IV	3	5	8	38
C-I	23	3	26	89
C-II	1396	968	2364	59
C-III	1056	1024	2080	51
C-IV	1302	1141	2443	53
TOTALS	15527	13327	28854	54

SATURDAY 2 AUGUST DAY 44

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	11	3	14	79
A-II	1362	910	2272	60
A-III	703	596	1299	54
A-IV		2	2	0
G-I	26	10	36	72
G-II	2486	2414	4900	51
G-III	331	282	613	54
G-IV				
S-I	21	3	24	88
S-II	1015	888	1903	53
S-III	731	842	1573	47
S-IV				
R-I	12	4	16	75
R-II	1371	1024	2395	57
R-III	1570	1569	3139	50
R-IV				
C-I	36	4	40	90
C-II	2134	1637	3771	57
C-III	681	607	1288	53
C-IV	2323	1799	4122	56
TOTALS	14813	12594	27407	54

SUNDAY 3 AUGUST DAY 45

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	2		2	100
A-II	392	438	830	47
A-III	226	273	499	45
A-IV		1	1	0
G-I	5	6	11	46
G-II	499	857	1356	37
G-III	117	148	265	44
G-IV				
S-I	22	1	23	96
S-II	369	378	747	49
S-III	239	422	661	36
S-IV				
R-I	2	2	4	50
R-II	469	530	999	47
R-III	433	697	1130	38
R-IV	2		2	100
C-I	11	2	13	85
C-II	531	511	1042	51
C-III	178	219	397	45
C-IV	401	476	877	46
TOTALS	3898	4961	8859	44

MONDAY 4 AUGUST DAY 46

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	7		7	100
A-II	843	711	1554	54
A-III	350	293	643	54
A-IV				
G-I	7	5	12	58
G-II	834	801	1635	51
G-III	196	210	406	48
G-IV				
S-I	17	2	19	90
S-II	788	605	1393	57
S-III	596	640	1236	48
S-IV	2	4	6	33
R-I	5	2	7	71
R-II	1076	809	1885	57
R-III	1031	1116	2147	48
R-IV				
C-I	18	5	23	78
C-II	929	725	1654	56
C-III	235	240	475	50
C-IV	794	680	1474	54
TOTALS	7728	6848	14576	53

TUESDAY 5 AUGUST DAY 47

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	4		4	100
A-II	571	603	1174	49
A-III	278	300	578	48
A-IV		1	1	0
G-I	7		7	100
G-II	682	838	1520	45
G-III	235	219	454	52
G-IV				
S-I	15		15	100
S-II	587	490	1077	55
S-III	530	591	1121	47
S-IV				
R-I	6	2	8	75
R-II	906	640	1546	59
R-III	731	778	1509	48
R-IV		2	2	0
C-I	10	6	16	63
C-II	525	460	985	53
C-III	124	193	317	39
C-IV	563	458	1021	55
TOTALS	5774	5589	11355	51

WEDNESDAY 6 AUGUST DAY 48

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	6	1	7	86
A-II	1574	1042	2616	60
A-III	730	529	1259	58
A-IV				
G-I	3	3	6	50
G-II	1615	1438	3053	53
G-III	560	465	1025	55
G-IV				
S-I	31	6	37	84
S-II	1668	1037	2705	62
S-III	955	861	1816	53
S-IV	1	1	2	50
R-I	2	2	4	50
R-II	2171	1102	3273	66
R-III	966	841	1807	54
R-IV	6	2	8	75
C-I	25	7	32	78
C-II	1133	779	1912	59
C-III	286	237	523	55
C-IV	1670	1179	2849	59
TOTALS	13402	9532	22934	58

THURSDAY 7 AUGUST DAY 49

VEGETATION	MALES	FEMALES	TOTAL	PERCENT MALES
A-I	3	3	6	50
A-II	1104	892	1996	55
A-III	409	384	793	52
A-IV	2	2	4	50
G-I	3	2	5	60
G-II	1199	1112	2311	52
G-III	280	243	523	54
G-IV				
S-I	9	1	10	90
S-II	1128	885	2013	56
S-III	425	435	860	49
S-IV				
R-I	5		5	100
R-II	1151	861	2012	57
R-III	662	671	1333	50
R-IV				
C-I	9		9	100
C-II	1018	949	1967	52
C-III	179	216	395	45
C-IV	980	969	1949	50
TOTALS	8566	7625	16191	53