SEASONAL VARIATIONS OF MITES OF THE SUBORDER MESOSTIGMATA (ACARINA) FROM SOUTH FLORIDA TURFGRASSES

By

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A DISSERTATION PRESENTED TO THE GRADUATE COUNCIL OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

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DEDICATION

To my Parents

Glyn T. H. Ing and Nancy C. Ing

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Abstract of Dissertation Presented to the Graduate Council of the University of Florida in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

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A survey of mesostigmatid mites was conducted on experimental and landscaping turfgrass plots in Ft. Lauderdale, Florida. From three plots each of St. Augustinegrass, bahiagrass and bermudagrass, one core sample consisting of soil, thatch and grass was taken every other week from June, 1974, to June, 1975. Sample cores were 20 cm in diameter and 10 cm deep. Mites were extracted with Berlese funnels for 11-14 days and were preserved in 80 percent ethanol and mounted on microscope slides.

The major arthropod groups collected from core samples were mites, Collembola, ants, scales and thrips. Among the mites collected were 13 superfamilies of Cryptostigmata, at least 18 families of Prostigmata, two families of Astigmata, and 14 families with 72 species of Mesostigmata. The mesostigmatid families and numbers of species in each family were: Macrochelidae (5), Laelapidae (16), Phytoseiidae

(14), Ascidae (15), Macronyssidae (1), Rhodacaridae (7), Parasitidae (2), Polyaspidae (1), Podocinidae (1), Veigaiidae (1), Parantennulidae (1), Cercomegistidae (1), Eutrachytidae (2), and Uropodidae (5). Populations of the arthropod groups, mite suborders and common mesostigmatid families, genera and species were compared according to seasons and grass species from which they were collected. The effects of temperature and precipitation on mite populations were discussed. Diversity, measured by Shannon-Weiner index, was calculated for mesostigmatid families and species and was compared according to seasons and grass species. Biological and ecological information on each of the mesostigmatid species was reviewed and discussed.

INTRODUCTION

Turfgrass is important to a contemporary society for several reasons. Aesthetically, turf provides a background for landscaping, reduces glare and lowers temperatures of ground and surrounding space, thus beautifying our environment and making it more comfortable in which to live. From the utility standpoint, its use prevents soil erosion, controls dust, and provides a clean and pleasant surface for work and recreation (Smith 1975). Furthermore, the production and maintenance of turfgrass is a large industry that has a significant place in our agricultural economy. In 1970, Americans spent over a billion dollars for the establishment and maintenance of turfgrass on residential lawns (Crockett et al. 1975). In the state of Florida, in the year ending in June, 1974, 911,000 acres (368,676 ha) of turfgrass were being maintained at an annual cost of 450 million dollars. An additional 73 million dollars was invested in the establishment of 31,000 acres (12,545 ha) of new turf. The combined cost of turf maintenance and new turf was equal to a third of the total 1974 production expenditures on Florida farms (Fla. Dept. Agr. and Consumer Serv. and Fla. Crop and Livestock Reporting Serv. 1976).

Turfgrass consists of a complex of parts including the leaves, stems and roots of the grass plant, and a composite layer of plant debris, roots and stolens generally referred to as thatch (Streu 1973). A large number of invertebrate pests inhabit this environment and can cause economic damage through their feeding activity. The major invertebrate pests of turfgrass in Florida are southern chinch bug, *Blissus insularis* Barber; sod webworms, *Herpetogramma phaeopteralis* Guenee and *Crambus* spp.; fall armyworm, *Spodoptera frugiperda* (Smith); mole crickets, *Scapteriscus acletus* R. and H. and *S. vicinus* Scudd.; hunting bill bug, *Spenophorus venatus vestita* Chittenden; white grubs, *Phyllophaga* spp., *Cotinis nitida* (L.) and *Cyclocephala* spp.; scale insects, *Antonina graminis* (Mask.) and *Odonaspis ruthae* Kot.; spittle bug, *Prosapia bicincta*; bermudagrass mite, *Eriophyes cynodoniensis* (Sayed); ground pearls; and nematodes (Short 1976).

Turfgrass is also inhabited by a large number of non-pests including insects, mites, and nematodes forming a complex community which interacts with the plant and the thatch as well as with the pest organisms. Continued and heavy pesticide usage in turfgrass may cause reductions of predators and decomposers and an increase in herbivore population in the turfgrass ecosystem. These conditions in turn will contribute to and severely aggravate thatch and pest problems commonly associated with high-maintenance turfgrass (Streu 1973). In establishing an effective pest management system for turfgrass, it is essential to have a thorough understanding of the ecosystem involved. This knowledge enables us to speculate on the effects of cultural practices and pesticide applications, potential secondary pests and possible beneficial organisms, and forms the basis of intelligent decision making.

In 1974, a comprehensive turfgrass faunal survey was conducted by Dr. James A. Reinert at the Agricultural Research Center, Fort Lauderdale, Florida. On nine experimental plots planted in St. Augustinegrass, bahiagrass and bermudagrass, core samples consisting of soil, thatch and grass were removed biweekly to determine insect, mite and other invertebrate fauna. In addition, 10 sweeps per plot with a sweepnet was used for sampling insects associated with above-ground part of the grasses. The present study is concerned with mite species of the suborder Mesostigmata which includes those mite families most frequently studied in biological control of mites and insects.

The primary aim of this study was to determine the mite species present in turfgrass untreated with pesticides as baseline data for comparison with treated turfgrass, and, where possible, to derive quantitative population information such as population density, seasonal and habitat distributions, and co-relationships among the mites.

It is hoped that these findings will provide a background for future studies on turfgrass, and for determining the effects of repeated use of pesticides in the environment and their effect on the soil populations of arthropods.

LITERATURE REVIEW

A review of faunal studies on mites in the state of Florida showed that there are surveys based on both mite taxa and habitat or ecosystem. Among the ecosystems, the citrus groves are the most intensively and extensively studied. The mesostigmatid family Phytoseiidae is the best understood among the mite taxa.

Muma (1955) listed 11 species of Phytoseiidae associated with Florida citrus. Two of these were later placed in the family Blattisocidae (treated as a subfamily of Ascidae in the present study), leaving nine bonafide phytoseiids. In a revision of the above work, Muma (1964a) expanded the list of citrus-associated Phytoseiidae to 10 genera and 32 species. Keys, diagnostic characters, and collection records were provided for each genus and species.

In other families of mites found associated with citrus in Florida, Muma (1960) recorded eight species in the family Cunaxidae, Muma (1964b) recorded 12 species of Cheyletidae, and Attiah (1970) described two new genera and 20 new species of tarsonemid mites.

Muma et al. (1975) compiled a systematic list of predators and parasites of insects and mites associated with Florida citrus. A total of 17 mite families represented by

138 species were listed. Also given were evaluations of importance, seasonal abundance, and distribution records. In a non-technical handbook for field identification of common groups of mites found in citrus groves, Muma (1975) covered more than 230 species of mites belonging to at least 49 families. Habitat, biology, and economic data were included for many species. Keys for families and diagnostic characters for families, genera and species were provided for the 10X-magnifying-lens user in the field.

Some population studies of mites on Florida citrus were conducted by Muma (1964c, 1965). In a Phytoseiidae population study from May 1960 to February 1962, Muma (1964c) took leaf samples from citrus groves in five growing areas in Florida. Of the 16 species of Phytoseiidae found, eight were sufficiently common to permit determination of a sex ratio. Populations of these eight common species were compared according to citrus growing areas and to seasons of the year. The most common species in each growing area and in each season was Amblyseius peregrinus (Muma).

Muma (1965) conducted a three-year study on mite population in 15 essentially untreated, widely distributed citrus groves. Mite samples were collected from fruit, leaves, bark and litter four times a year, and mean populations were recorded for each strata, grove, season, and geographic area. Seventeen species or species complexes were sufficiently common or abundant to be of possible importance to the development of other mite populations in citrus groves. These were discussed as either injurious, predatory, or scavenger species. Also discussed were the host-predator associations possibly important in the economy of injurious species.

The population of Phytoseiidae from sand-pine litter in Florida was studied by Muma (1968). He collected 18 species of phytoseiids, all belonging to the subfamily Amblyseiinae. The seasonal and geographical distributions of the most common species were studied, and a comparison was made of the common litter phytoseiids from litter of sand-pine, citrus, and mixed mesophytic hardwood hammocks composed primarily of oaks, sweet gum, and hickories.

Muma and Denmark (1971) reviewed the Phytoseiidae in Florida. Eighty-six species were recorded and their diagnoses, type data, habitats, biology, and distribution were provided. Also included were diagnostic keys and distributional maps.

In a series of papers on some Oribatei mites of Florida, Jacot (1933, 1935, 1936, 1938) recorded and described 18 genera and 42 species of mites belonging to the family Phthiracaridae and subfamily Galumninae.

In mite fauna of lychee in Florida, Dekle (1954) recorded three species of tetranychid mites. DeLeon (1956) recorded an additional five mite species and described two new genera and five new species of Tarsonemidae.

Gladiolus was reported (Kelsheimer 1956) to be attacked by two species of spider mites in Florida. Seven species of mites were found to be associated with gladiolus corms (Engelhard 1969, Poe 1971). At least one of these mites, Lasioseius subterraneous Chant, was reported as a predator.

From an experimental red worm bed in the Quincy area, Tappan (1959) collected two species each in the families Macrochelidae and Uropodidae. One of the uropodids, Fuscuropoda agitans (Banks) was reported eating worm's food. The other, F. marginata (Koch), however, was a predator of F. agitans.

In a preliminary survey of ectoparasitic mites of the house sparrow and mockingbird in Florida, Phillis and Cromroy (1972) recorded three species of Macronyssidae. Phillis et al. (1976) recorded new host and distribution records for the above species, an additional species of Macronyssidae, and a species of Dermanyssidae.

Dohany and Cromroy (1976) recorded eight species of chiggers (larvae of Trombiculidae) in Florida from litter samples and tree holes, and with black plates. Of these species, six were new to the state of Florida and two species were recorded from their hosts for the first time. Ibrahim (1976) recorded two additional chigger species and described a new species from north central Florida.

In an acarine survey on six species of ornamental plants in Gainesville, Florida, Yusoh (1976) found mites belonging to 16 families, 36 genera and 45 species. The mite families were categorized into phytophagous, predaceous, and saprophytic groups and the populations of these groups were compared for each host plant.

Our knowledge of mites on turfgrass is meager compared to that on citrus. Wolfenbarger (1953) collected two species of mites from St. Augustinegrass. They are *Paratetranychus stickneyi* McGregor and a new species, with the former also feeding on bermudagrass. He described the symptoms of mite infestation and stated that the use of sulfur seemed to provide effective control. A special grass survey (Link et al. 1955) was conducted in Monroe, Dade and Broward counties of Florida from July 1954 through March 1955. The purpose of the survey was to collect, identify, and record all arthropods found on turf. However, only four mite species were found, together with other arthropods. These are *Cunaxoides andrei* Baker and Hoffman, *Amblyseius* sp., *Galumna* sp., and *Scheloribates laevigatus* (Koch). In a survey on predaceous mites associated with bermudagrass mite, *Eriophyes cynodoniensis* (Sayed), Johnson (1975) collected samples of crown, stem and leaves of bermudagrass. The most common mites he found belonged to the family Uropodidae. He recorded the following predaceous species:

Cunaxidae: *Neocunaxoides andrei* (Baker and Hoffman)

Cunaxa simplex (Ewing)

Dactyloseious sp.

Eupodidae: *Eupodes* near *ocellatus*

Tydeidae: *Tydeus pertydeus tuttlei* Baker

Paralorryia near *italica*

Macrochelidae: *Macrocheles muscaedomesticae* (Scapoli)

M. near *rothamstedensis*

Phytoseiidae

Outside the state of Florida, there is also very little work done on mites associated with turfgrass. Tuttle (1963) recorded the following mites from bermudagrass in Arizona:

Laelaptidae: *Cosmolaelaps* sp.

Aceosejidae: *Proctolaelaps* sp.

Phytoseiidae: *Typhlodromus* (*A.*) *obtusus* group

Amblyseiopsis n. sp.

Uropodidae: *Leiodinychus* sp.

Tarsonemidae: *Stenotarsonemus spirifex* (Marchal)

Tydeidae: several spp.

Cunaxidae: *Cunaxoides andrei* Baker and Hoffman

Cunaxoides n. sp.

Caligonellidae: *Molothrognathus crucis* Summers and Schlinger

Molothrognathus n. sp.

Tetrarychidae: *Petrobia latens* (Müller)

Schizotetranychus eremophilus McGregor

Oligonychus pratensis (Banks)

Oligonychus stickneyi (McGregor)

Cheyletidae: *Paracheyletia wellsi* (Baker)

Eriophyidae: *Aceria neocynodonis* Keifer

Erythraeidae: *Balaustium* sp.

Leptus sp.

Ephilohomanniidae: *Ephilohomannia cylindrica* (Berlese)

Carabodidae: *Tectocepheus* sp.

Oribatulidae: *Zygoribatula* sp.

In a study on predators of the hairy chinch bug, *Blissus leucopterus hirtus* Montadon, from bluegrass in New Jersey, C. Cruz and H. T. Streu (unpublished manuscript) studied the predation of several mite species on chinch bugs and Collembola in the laboratory, and population densities of Mesostigmata in relation to chinch bug populations, and discussed the effects of application of chlordane on mesostigmatid mites. They recorded the following mites:

Erythraeidae: *Balaustium* spp.

Erythraeus spp.

Parasitidae: *Parasitus* sp.

Eugamasus sp.

Pergamasus sp.

Phytoseiidae: *Amblyseius* sp.

Neoseiulus setulus (Fox)

N. gracilis (Muma)

Fundiseius spp.

Proprioseiopsis spp.

Ascidae: *Asca nova* Willmann

Lasioseius mcgregori (Chant)

other *Lasioseius* species

Macrochelidae: *Macrocheles muscaedomesticae* (Scopoli)

METHODS AND MATERIALS

This survey was conducted on the experimental and landscaping turfgrass plots located within the University of Florida Agricultural Research Center at Fort Lauderdale, Florida.

Mites were collected from nine plots of grasses ranging in area from about 115 m^2 to about 800 m^2. The three grass species most commonly cultivated in south Florida were sampled. There were three plots each of St. Augustinegrass, *Stenotaphrum secundatum* (Walt.) Kuntze; bahiagrass, *Paspalum notatum* Flugge; and bermudagrass, *Cynodon dactylon* (L.) Pers. The layout of the survey plots and the grass species and varieties are presented in Appendix I. All the turf plots were under a low-maintenance program and no pesticide was applied during the survey. Two plots of St. Augustinegrass and one plot of bahiagrass (plots 2, 3 and 4) were marked off from landscape lawns. These were watered about two or three times per week. The remainder of the plots were experimental turf plots that received approximately 3 mm of water per day. All watering was in the form of overhead sprinkling.

One core sample consisting of soil, thatch and grass was taken from each plot every other week from June, 1974, to

June, 1975. The samples were taken at random from within an approximately 6 m x 6 m area situated in the middle of each plot, in late morning or early afternoon after the dew had dried. Sample cores were taken with a soil of corer 20.3 cm inside diameter and about 10 cm deep. The plugs were then placed up-side-down into Tullgren's modification of Berlese funnels so that the grasses were against the double layer of cheese cloth in the bottom of funnels, while the soil was exposed to the 40W incandescent bulbs. This was done according to the belief that soil animals can escape through soil surface more easily than they can to deeper soil layers. The funnels were run for 14 days for moist samples and 11 days for drier samples. The soil and grass animals were collected and preserved in 80 percent ethanol in 1-pint mason jars (476 ml). Mites were separated from other animals under 20X of a binocular dissecting scope. The numbers of mites and common groups of insects from each sample were counted. These insects are Collembola, ants, scale insects, and thrips. The sorted mites were preserved in 80 percent ethanol in 8 ml screw-cap glass shell-vials. Approximately 100 mites were randomly extracted from each sample vial with a flattened dissecting needle. These were mounted in Hoyer's modified Berlese medium on microscope slides. After drying the slides at 50°C for four days the coverslips were ringed with Glyptal or pink finger-nail polish. The specimens were identified by use of a phase-contrast microscope with magnifications of 100X, 200X, 450X, or 1,000X. During a preliminary sorting, mites of the suborders Astigmata, Prostigmata, Cryptostigmata, and Mesostigmata were separated. Notes were kept on the families of Astigmata and Prostigmata, and superfamilies of Cryptostigmata. Mesostigmatid mites were identified to families, genera, and species.

During the time of this survey, climatic data were recorded daily with the standard meteorology station equipment located within the Agricultural Research Center. Maximum and minimum temperatures, precipitation, and evaporation of the previous day were logged at around 8 AM each day.

The stability of an ecosystem is often thought to depend on the diversity of its component species of producers and consumers (Price 1975, Wilson and Bossert 1971). Diversity in this case refers to not only the number of species but also the relative abundance of each. The most commonly used measurement for diversity is the Shannon-Wiener index H', where

$$H' = -\Sigma \, Pi \log_e Pi$$

and Pi is the proportion of the ith species or group of species in the total sample. Diversity in a community increases when there is an increase in the number of species and also when species become more evenly distributed in abundance.

Using the Shannon-Wiener index, a comparison was made of the diversity of major groups of mesostigmatid mites among the months of the survey year, and among the grass species.

In order to estimate the ratio of mites in the four suborders, a drop-sampling method was devised. The tip of an eyedropper was filed down so that the opening was enlarged to an inside diameter of about 3 mm. This was to insure that the largest mites in the samples could freely pass through. The glass tube of the eyedropper was calibrated and marked at 1/8 ml intervals.

A vial containing mites from a complete sample was uncapped and the 80 percent ethanol in the vial was filled to neck level (8 ml). The vial was stopped-up with a thumb, turned up-side-down, shaken vigorously 10 times, and turned immediately right-side-up. The tip of the eyedropper was inserted into the middle of the vial. Within 1 sec. after cessation of shaking of the vial, before the mites could settle again, a measured amount of 1/8 ml of liquid with mites was sucked into the eyedropper. The eyedropper was then held upright for 1 min., at the end of which all the mites in the dropper will have settled to around the opening. One to two drops of the liquid with all the mites were then placed into the well of a cavity slide, covered with a glass coverslip, and examined under 100X of a phase-contrast microscope. The number of mites in the suborders Astigmata, Prostigmata, Cryptostigmata, and Mesostigmata were counted. This whole procedure was repeated three more times for each vial without replenishing the ethanol taken out each time. The means derived from the four drop-samples for each sample vial were used for estimating the ratio of the four mite suborders.

RESULTS

The major groups of arthropods collected from Berlese funnel samples are mites, Collembola, ants, scales and thrips. The mean numbers of these groups of animals collected in each month of the survey year are presented in Appendix II and Figures 1-5. The mean numbers of these animals collected from each of three species of turfgrass are presented in Table 1. As a further breakdown of the above data, the mean numbers of specimens for each month and for each grass species are shown in Appendix III.

Mites from four suborders were found in the slide samples. These are Cryptostigmata, Prostigmata, Astigmata, and Mesostigmata. The mean numbers of these four suborders of mites are shown for each month of the survey year (Appendix IV and Figure 6-9), for each species of turfgrass (Table 2), and for each month and each species of turfgrass (Appendix III). The means were transformed into percentages of total mites. Percentages of four mite orders in slide samples are shown for each month (Table 3) and for each grass species (Table 4). Owing to the scope of the present study, only specimens of the suborder Mesostigmata were identified to species and their numbers and occurrences were recorded (Table 5). A total of 14 families and 72 species of mesostigmatid mites were identified. The remaining suborders were sorted out and the occurrences of families or superfamilies were recorded, but their occurrences by seasons and plots were not recorded. A list of superfamilies of Cryptostigmata and families of Prostigmata and Astigmata found in slide samples is shown in Table 6.

Among the 14 families of Mesostigmata recorded from slide samples, only seven were numerous enough to warrant any kind of population study. These were termed major families of Mesostigmata. They are Macrochelidae, Laelapidae, Phytoseiidae, Ascidae, Rhodacaridae, Uropodidae, and Eutrachytidae. The mean numbers of these major families in each month are shown in Appendix V and Figures 10-16. The mean numbers from each grass species are shown in Table 7.

The genera and species of Mesostigmata with an overall average of one or more specimens per sample were termed major genera and species. The genus Proprioseiopsis of Phytoseiidae was also included as a major genus although its mean specimen number was below one. This was because of the high number of species (eight) in the genus. The major genera were Proprioseiopsis, Hypoaspis, Macrocheles, and Asca. The major species were Hypoaspis near claviger (Berl.), Pseudoparasitus stigmatus (Fox), Ololaelaps sp., Macrocheles near insignitis Berl., Leonardiella sp., and Oplitis communis Hunter and Farrier. The mean numbers of these major genera and species in each month are shown in Appendix VI and Figures 17-26. The means in each grass species are shown in Table 8.

Climatic data recorded daily during the survey were organized by each month of the survey year. Maximum and minimum temperatures are averages of daily recordings over each month, and are shown in Figure 27. Precipitation is the cumulative amount in each month, and is shown in Figure 28. Evaporation measurements were hampered by equipment breakdowns which occurred several times during the survey. These measurements are not used in the present study. An attempt was made to find the level of association of populations of mites and other arthropods with temperature and precipitation. Correlation coefficients were calculated from Berlese samples for the major arthropod groups (Table 9), from slide samples for mite suborders and major families (Tables 10 and 11), and from drop samples for mite suborders (Table 12).

Comparison of diversity of mesostigmatid mites was made at two different levels; one at the family level and the other at the species level. The Shannon-Wiener index (H) was calculated separately for the 14 families and the 72 species found in suborder Mesostigmata. At both levels, diversities were compared among the species of turfgrass (Table 13) and among the months of the survey year (Appendix VII and Figure 29).

From drop samples, mean numbers of mites in each of the four suborders are shown for each grass species (Table 14) and for each month (Appendix VIII and Figures 6-9). For purpose of comparison, these means were transformed into percentages of total mites. Shown in Table 15 are percentages of four mite suborders in drop samples compared by month. In Table 16 they are compared by grass species.

In order to find the levels of association and interrelationships among the arthropod and mite groups, correlation coefficients were calculated for these groups. Correlation coefficients of the major arthropod groups from Berlese samples are shown in Table 17. Correlation coefficients of the four mite suborders from slide samples are shown in Table 18. Correlation coefficients of the four mite suborders from drop samples are shown in Table 19. Correlation coefficients of the major families are shown in Table 20.

Many mite species have been found to be associated with ants. Some species in the superfamily Parasitoidea are scavengers of bodies, exuvia, and other debris in ant nests. Many genera of Uropodoidea are also myrmecophilous and probably feed on the mycelia and spores of fungi, and on organic detritus (Hughes 1959). Since a large number of ants have been found in the turf samples of this survey, it is likely that some of the mite species recorded may in some way be associated with ants. To find this possible association, correlation coefficients were calculated for ants with all mesostigmatid mite species found in this survey. Species with correlation coefficient values higher than 0.1 are listed in Table 21.

To facilitate comparison, data compared by month were further compared by the four seasons: summer (July, August, September), fall (October, November, December), Winter (January, February, March), and spring (April, May, June).

DISCUSSION

Environmental Influence on Mite Populations

The correlation coefficients for precipitation and population numbers were low in all the groups, indicating low level of influence by precipitation on population (Tables 9-12). This is to be expected because of the regular watering the turf plots received during the survey. However, the association between temperature and population numbers was, in most cases, also weak. Most correlation coefficients were either negative or positive with very low values. The low values may be due to the warm climate in Ft. Lauderdale, Florida, where winter temperatures never reached freezing during the survey. Only twice did the daily minimum temperature dip below 4°C. Only Collembola from Berlese samples and mesostigmatids from slide samples have correlation coefficients with temperatures with numerical values higher than 0.3 (Tables 9 and 10). The fact that these coefficients are negative suggests the possibility that, in Ft. Lauderdale's hot summer and warm winter, the Collembola and mesostigmatid mites are more numerous during the cooler seasons.

Seasonal Variations of Mite Populations

From Berlese samples (Figs. 2-6), all arthropod groups except ants reached their lowest mean numbers in the summer.

All except Collembola had means with two major peaks in the fall and spring. In Collembola the peaks are in the fall and winter.

From slide samples, the mean number of mites in the suborder Cryptostigmata is rather evenly distributed throughout the year, except for a very low point in early summer (Fig. 7). In Prostigmata the means reached a lower peak in early fall, then a higher peak in spring (Fig. 8). In Astigmata the means reached the highest peak in the fall (Fig. 9). However, the numbers of Astigmata in the samples are far too low for a population trend study. The mean number of mesostigmatids remained high from early fall to early spring, with lowest point between spring and summer (Fig. 10).

From drop samples, mean numbers of the suborders Astigmata and Mesostigmata are consistently even throughout the survey year (Figs. 9 and 10). Cryptostigmata exhibit a high fall and winter population (Fig. 7). In a survey of hemlock-yellow beech forest soil mites in Michigan, Wallwork (1959) found that population number of cryptostigmatid mites was low in summer and highest in winter, but was reduced in late winter. The population changes in his survey were much more drastic than in the present study. This may have been due to the much greater temperature variation in Michigan, where ground litter was completely frozen for the greater part of the winter. Wallwork suggested from laboratory observations that one of the causes for this late-winter reduction could be the predation on juvenile cryptostigmatids by other mites. The Collembola population in Wallwork's survey was also low in summer and increased greatly in winter, and followed closely the pattern of juvenile cryptostigmatid mites. Since Collembola are subjected to attack by predatory mites in the same way as juvenile cryptostigmatids, Wallwork (1959) suggested that their populations may have been affected by some of the same factors influencing population size of juvenile cryptostigmatids. The means of Prostigmata exhibit the same trend as those in slide samples (Fig. 8).

The major families, Macrochelidae, Ascidae, and Phytoseiidae (Figs. 13, 15 and 16) have the most specimens present in the fall and winter. Muma found that all the common phytoseiids from citrus leaves (1964a) and litter (1964c) in Florida and most of the common species from Florida sand-pine litter (1968) exhibited a spring or winter-spring peak abundance. However, Muma's definition of winter includes the months December, January and February, and spring includes March, April and May. Proprioseiopsis gracilisetae (Muma), the dominant phytoseiid species in the present study, was most numerous in the fall and winter. This species from sand-pine litter in Oviedo, Florida attained peak populations in the spring and summer (Muma 1968). This difference in seasonal abundance could be due to the fact that Oviedo is located in central Florida, about 170 miles north of Ft. Lauderdale.

All major genera and most of the major species exhibit similar population trends to the families to which they belong (Figs. 20-29). Exceptions are Pseudoparasitus stigmatus and Ololaelaps sp. P. stigmatus was most numerous in fall and winter to early spring (Fig. 25). Ololaelaps sp. was most numerous in winter and spring (Fig. 25). Both species were similar to Hypoaspis near claviger in that the populations were lowest in late spring and early summer.

A glance through Table 5 revealed that among the relatively common species of Mesostigmata with 50 or more specimens collected in slide samples, the majority showed peak abundance in fall or winter. Exceptions are Leonardiella sp., with peak population in spring; Oplitis communis, abundant in fall, winter and spring; Gamasiphis sp. 1, which is equally abundant throughout the year; and Hypoaspis near vacua sp. 1, which is more abundant in summer and fall. Of the four species, Oplitis communis is myrmecophilous (Hunter and Farrier 1975) and probably is subterranean in habitat; Leonardiella sp. is probably also myrmecophilous (Table 21); Gamasiphis sp. 1 is probably a soil mite; the habitat of Hypoaspis near vacua sp. 1 is unknown, while H. vacua (Michael) has been recorded from moss and ant nests (Evans and Till 1966). It is conceivable that subterranean mites would be influenced by seasonal temperatures differently from mites living above the ground.

Interrelationships Among Mite Groups and Arthropods

Among the mean numbers of arthropod groups, only thrips have a moderately high correlation coefficient (0.41) with mites (Table 17) indicating that some of the mites may be predators of thrips. Many mite species are predators of Collembola (C. Cruz and H. T. Streu, unpublished manuscript; Sheals 1957). The low value of correlation coefficient between mites and Collembola (0.18) does not suggest this relationship, and is most likely due to the fact that the majority of mite species from this survey are not Collembola predators. In slide samples, none of the mite suborders have a strong relationship with one another (Table 18). Among the mite suborders from drop samples, moderate positive correlationships are found between Cryptostigmata and Prostigmata (0.47), and between Prostigmata and Mesostigmata (0.33) (Table 19). None of the major families has high correlation coefficients with each other (Table 20).

Among all the mesostigmatid species, 10 have correlation coefficients with ants higher than 0.1 in absolute values (Table 21). Only two of the 10 species are over one in overall mean specimen numbers. These are *Hypoaspis* near *claviger* and *Leonardiella* sp. Of the 10, only *Leonardiella* sp. has a moderately high correlation coefficient with ants (0.43). This merely suggests that this mite is probably associated with ants. It does not preclude the possibility that other mite species may also be myrmecophilous. A high or low correlation coefficient only indicates a numerical relationship. Many of the mite species were not numerous enough to be present in most of the Berlese samples, and their relationship with ants can only be observed through biological studies and not from statistical analysis. It is interesting to note that Oplitis communis, which is one of the major species, and is known as an ant-associate (Hunter and Farrier 1975), has such a low correlation coefficient with ants (-0.04).

Evaluation of Sampling Methods

The purpose for taking drop samples was to estimate the total numbers and the proportions of the four suborders of mites collected from Berlese samples. The purpose of taking slide samples was for identification of mite species and also for estimating proportions of mite groups. Both of these are subsamples of Berlese samples. The total mite numbers from each slide and drop samples were compared with mite numbers from the Berlese sample from which they were taken in order to determine the accuracy of these sampling methods. Table 22 shows the correlation coefficients of total mite numbers of slide and drop samples with those from whole Berlese samples. The correlation coefficient between mite number from drop samples and Berlese samples is 0.79, which indicates a strong positive relationship between the two. This shows that the drop sampling method is adequate for its purpose. On the other hand, the corresponding number between slide and Berlese samples is only 0.12, indicating a weak relationship. This is to be expected since slide sampling was not designed for estimating total mite numbers.

A comparison was made of overall means and percentages of the four suborders from both drop and slide samples (Table 23). It is apparent that there is a much higher percentage of mesostigmatid mites in the slide samples. Since drop samples were taken with a mechanical device, they should be less influenced by human bias, which can easily occur during sorting for slide mounting. The discrepency between the results of the sampling methods may be due to the comparatively larger physical sizes of mesostigmatids and their well-developed body shields and leg segmentation, making them more conspicuous and easier to be picked out than other mites.

The above comparisons have shown that population estimates ought to be made from Berlese samples for the arthropod groups, and from drop samples for the mite suborders. In order for slide sampling to yield more valid estimates of population numbers, it should include all or a fixed proportion of the mites in the Berlese samples.

Ibarra et al. (1965) found that natural populations of free-living soil mites and Collembola exhibit a contagious (clustered) distribution and tend to aggregate in areas of choice food and favorable microclimatic conditions. They warned that caution must be used in estimating the population of a whole field from a few samples taken. However, in a turfgrass environment, where maintenance practices keep conditions rather homogeneous, arthropod populations may have less tendency to aggregate as in cattle and sheep pastures where Ibarra et al. did their study.

Diversity

Diversities of mesostigmatid familes and species were both significantly higher in St. Augustinegrass than in the other two grass species (Table 13). When compared by month (Appendix VI and Fig. 30), both diversities were higher during fall and winter, with family diversity peaking in the fall and species diversity peaking in early winter.

Discussions of Biological and Ecological Information

Only those species that have been identified to the species level and with known biological or ecological information are discussed individually. Species identified only to genera or families are discussed collectively at these levels.

Family Macrochelidae

Mites of this family are widely distributed in a variety of habitats, such as in humus, soil, decaying wood, and on insects (Evans 1957). Five species were collected in the present survey.

Macrocheles near *insignitis* Berl.

This was the most common macrochelid mite and was abundant in all three grasses. Evans and Browning (1956) collected one female of *M. insignitis* from 'a hot bed.' Muma et al. (1975) collected *M. insignitis* from citrus litter in Florida.

Macrocheles near *mammifer* (Berl.)

This species was common in bermudagrass, but was very rare or absent in the other grasses. The species *M. mammifer* has been recorded from cattle and sheep pastures of bluegrass in Kentucky (Rodriguez and Ibarra 1967).

Macrocheles muscaedomesticae (Scopoli)

This mite was similar to the preceding species in that it was common in bermudagrass but was rare or absent in other grasses. This species is cosmopolitan in distribution (Evans and Browning 1956). It is common in manure heaps (Axtell 1963, Costa 1966a) and was recorded in cattle and sheep pastures in Kentucky (Rodriguez and Ibarra 1967). Commonly found phoretic on house fly, *Musca domestica* Linn., and other flies (Costa 1966a, Evans and Browning 1956), this mite is capable of harming the adult fly by biting through the intersegmental membranes (Jalil and Rodriguez 1970). *M. muscaedomesticae* feeds on eggs and first larval instar of the house fly and has been investigated as a possible biocontrol agent for the housefly (Filipponi 1955, Rodriguez and Wade 1961, Wade and Rodriguez 1961). Rodriguez et al. (1962) observed this mite feeding on the free-living nematode, *Rhabditella leptura* (Cobb) Chitwood, in the laboratory. Given equal choice, adult mites preferred house fly eggs over nematodes while nymphal mites preferred the nematodes. Ishikawa (1968) collected five females of *M. muscaedomesticae* on last larval instar of silkworm, *Bombyx mori* Linn., in Japan. Bregotova and Koroleva (1960) recorded this mite from rodents as well as from various Diptera in the U.S.S.R. C. Cruz and H. T. Streu (unpublished manuscript) regarded this mite, commonly found in turfgrass in New Jersey, as a predator of chinch bug eggs.

Glyptholaspis americana (Berl.)

This mite was reported by Costa (1966a) to be common in manure heaps in Israel. Muma et al. (1975) collected it from citrus litter in Florida.

Holostaspella bifoliata (Tragardh)

Only one specimen was collected from bermudagrass. This mite is world-wide in distribution, and has been recorded from soil, litter, earthworm culture, and from litter and bark of citrus in Florida. It has been found as a phonetic associate of *Trox* spp. in Florida, and is also associated with *Dichotomius carolinus* (Linn.), *Peromyscus leucopus*, *Taurocopris mimas* Linn., and *Phanaeus corythus* Har. It fed on nematodes (*Rhabditis* sp.) in artificial cultures, and may be expected to be a predator in its natural habitat (Krantz 1967).

Family Phytoseiidae

Phytoseiid mites are cosmopolitan in distribution. They are abundant in ground surface litter and on vegetation, and are also found in stored products, animal nests, and soil. Food habits include pollenophagus, and facultative and obligatory predators. Their food includes nectars, fungi, pollen, leaf hairs, insects, mites, and nematodes. However, since only a minority of species have been studied, our knowledge of phytoseiid food habits is still fragmentary (Muma 1971). All 14 phytoseiid species from this survey belong in the subfamily Amblyseiinae. Muma (1968) studied the sand-pine litter fauna in Florida and found that sand-pine litter phytoseiids were all amblyseiine mites. A study of phytoseiids in North Carolina forest litter also demonstrated an amblyseiine litter population (Muma et al. 1967). Muma (1968) stated that it is possible that other similarly restricted habitats will prove to be occupied by a single subfamily of phytoseiids. However, leaves of plants from sand-pine communities and Florida citrus plants and litter yielded both Amblyseiinae and Phytoseiinae (Muma 1968). Biology and food habits of all 14 species from this survey are unknown. The genus *Proprioseiopsis* that are found in litter live either on saprophagus or fungivorus mites or on fungus or non-living organic material (Muma 1971). None of the species were abundant in this survey.

Proprioseiopsis gracilisetae (Muma)

This species has been collected from hardwood and pine litter (Muma and Denmark 1971) and on *Rhododendron obtusum* (Lindl.) Planch. and *Podocarpus macrophyllus* (Thunb.) D. Don in Florida (Yusoh 1976).

Proprioseiopsis mexicanus (Garmen)

This species was described from *Zinnia* from Mexico. It has been recorded from litter of citrus, hardwood and pine in Florida (Muma et al. 1967). It has also been found in bermudagrass debris and St. Augustinegrass sod and on other plants (Muma and Denmark 1971).

Proprioseiopsis sarraceniae (Muma)

This mite was previously known only from leaf cups of *Sarracenia* (Muma and Denmark 1971).

Prorioseiopsis citri (Muma)

Muma (1964a) recorded this mite from bark and litter of citrus.

Proprioseiopsis cannaensis (Muma)

This mite has been recorded from bark and litter of citrus, morning glory leaves, *Canna* leaves, and *Pinus clausa* (Engelm.) Sarg. litter. All living specimens collected have been associated with *Brevipalpus* spp. infestations (Muma 1964a, Muma and Denmark 1971).

Proprioseiopsis rotundus (Muma)

This species has been recorded from bark and litter of citrus, fescuegrass (Muma 1964a), bahiagrass, Spanish moss, *Tillandsia usneoides* Linn., and other plants (Muma and Denmark 1971).

Proprioseiopsis asetus (Chant)

This mite has been recorded from citrus plants and litter, *Pinus clausa*, *Senecio confusus* (DC.) Britten and Spanish moss (Muma and Denmark 1971).

Neoseiulus planatus (Muma)

This mite has been recorded from Citrus litter, fruit and bark (Muma 1964a), *Pisum* sp., and unidentified litter (Muma and Denmark 1971).

Neoseiulus paspalivorus (DeLeon)

This mite has been recorded from bermudagrass and bahiagrass (Muma and Denmark 1971).

Neoseiulus marinellus (Muma)

Only one specimen was found in a preliminary survey on the grass plots. It has been recorded from citrus fruit, bark and litter, from bermudagrass, bahiagrass, and other plants (Muma and Denmark 1971).

Chelaseius floridanus (Muma)

This species has been recorded from citrus leaves, bark and litter, and pine and oak litters (Muma and Denmark 1971).

Amblyseius rhabdus Denmark

This species has been recorded from St. Augustinegrass, *Sarracenia* sp., and Spanish moss on the ground (Muma and Denmark 1971). From studies of two other species, Muma (1971) concluded that mites in the genus *Amblyseius* are probably general predators.

Typhlodromips digitulus Denmark

This species has been recorded from bermudagrass, bahiagrass, and Spanish moss (Muma and Denmark 1971). From studying three other species in this genus, Muma (1971) concluded that species of *Typhlodromips* are facultative general predators that can survive on plant and non-living organic materials.

Family Laelapidae

Laelapid mites are found in a variety of habitats, including moss, humus, on small animals and in debris of their nests (Evans 1957). A total of 16 species in this family were collected in this survey, 13 of these are in the genus *Hypoaspis*. Members of the genus *Hypoaspis* have been collected from soils, stored products, insect nests, mammals and invertebrayes (Strandtmann and Crossley 1962).

Hypoaspis near *claviger* (Berl.)

This was the most common mite in this survey and was found in all the grasses. *H. claviger* has been recorded from various types of litter (Costa 1968), soil and rotting wood, and is probably predacious (Evans and Till 1966).

Hypoaspis near *vacua* (Michael) spp. 1 and 2

Two undetermined species from this survey are close to *H. vacua*. *H. vacua* has been recorded from moss and ant nests in Britain, and from ant nests in Australia and Italy (Evans and Till 1966).

Hypoaspis near *praesternalis* Willmann spp. 1, 2 and 3

Three species of *Hypoaspis* are close to *H. praesternalis*. *H. praesternalis* has been recorded from soil, grassland and marshes in Britain and Europe (Evans and Till 1966), and from litter, soil and sheep's fold in South Africa (Ryke 1963).

Hypoaspis near *aculeifer* (Canestrini)

All except two specimens of this species were collected from St. Augustinegrass. *H. aculeifer* is common in soil and litter, and has been recorded from the nest of *Riparia riparia* (Linn.) in Britain, from the nest of *Spalex ehrenbergi* Nehring in Israel, and the nests of a variety of rodents in the USSR (Costa 1966a, Evan and Till 1966).

Hypoaspis (*Laelaspis*) near *piloscutuli* Hunter

Hunter (1961) recorded *H. piloscutuli* from orchid plants imported from Mexico and from colonies of ants, *Eciton burchelli* and *Neivamyrmex gibbatus*, in Panama.

Hypoaspis queenslandicus (Womersley)

This species has been recorded from leaf debris in Australia (Womersley 1956), from pineapple field cores in South Africa (Ryke 1963), from donkey manure heap, sand, soil and litter in Israel (Costa 1966b), and from citrus litter in Florida (Muma et al. 1975).

Androlaelaps sp.

Muma et al. (1975) recorded four species of *Androlaelaps* from citrus leaves, bark and litter in Florida.

Pseudoparasitus stigmatus (Fox)

This common mite has been collected from rats in Puerto Rico and roots of tomato plants. It has been recorded from Cuba, Brazil, Puerto Rico, Costa Rica, Mexico, Florida and southern Georgia (Hunter 1966).

Ololaelaps sp.

Rodriguez and Ibarra (1967) collected *O. hemisphaera* Berl. in sheep pasture. Hurlbutt (1958) observed *O. placentula* Berl. feeding on two-spotted spider mites in laboratory. Muma et al. (1975) collected two species of this genus from citrus litter in Florida.

Family Ascidae

Species of Arctoseiinae are free-living inhabitants of the litter and humus layers of soils. The Platyseiinae inhabit a variety of subaquatic surface habitats, grasslands, and forest litters. Most species of Ascinae are free-living predators of the meiofauna of ground habitats. A few species of *Lasioseius* and *Proctolaelaps* regularly coinhabit the nests and shelters of certain vertebrates and arthropods (Lindquist and Evans 1965). Fifteen species of ascid mites were recorded in this survey.

Asca quinquesetosa Wharton

This species has been recorded from booby nests on Clipperton Island, and from litter, *Theretia peruviana*, and *Stephanotis floribundus* in Hawaii (Hurlbutt 1963).

Asca garmani Hurlbutt

This mite has been recorded from North and Central America. It has been collected from moss, forest litter, citrus litter, orchard sod, *Peromyscus* nests, in *Narcissus* bulb, on Portugese cypress, and in other organic materials (Hurlbutt 1963, 1968; Muma 1965). Hurlbutt (1968) found this species in coexistence with *A. aphidioides* (Linn.) and *A. neopallia* Hurlbutt in forest litter in Maryland. Hurlbutt (1963) observed females feeding on small Collembola, probably isotomids. He stated that specimens from Florida are smaller and have shorter setae than those from farther north.

Asca brachychaeta Hurlbutt

This species has been recorded from orchard sod, alfalfa stem, *Peromyscus* nests, grass, and on *Sarracenia*, the last in Florida (Hurlbutt 1963, 1968). It has been found in forest litter samples containing *A. aphidioides*, *A. garmani*, *A. nova* Willmann, and *A. nesoica* Athias-Henriot in Maryland. As in *A. garmani*, individuals from Florida are smaller and have shorter setae than those from farther north.

Lasioseius near *youcefi* Athias-Henriot

L. youcefi prefers wet places, and has been recorded from soil under stone, wet moss, and garden soil in Algeria (Athias-Henriot 1961).

Lasioseius scapulatus Kennett

This species has been recorded from compost, wet humus in a rock crevice, soil, citrus leaves and litter, strawberry, on *Paria* eggs on strawberry, and on Gramineae. It has been reported from California, Algeria, and Israel (Athias-Henriot 1961; Costa 1966a; Kennett 1958; Muma et al. 1975).

Proctolaelaps sp.

Mites of this genus are found in nests of small mammals, in decaying vegetation in soil, in stored food products feeding on tyroglyphids, and associated with bark beetles (Evans 1958). Tuttle (1963) recorded a species from bermudagrass in Arizona. Muma et al. (1975) recorded six species from citrus plants and litter in Florida.

Cheiroseius cassiteridum Evans and Hyatt

Evans and Hyatt (1960) recorded this mite in England as occurring with _Platyseius subglaber_ (Oudemans) in the roots of rushes and in _Sphagnum_. Athias-Henriot (1961) recorded it from wet soil in Algeria. Other members of this genus were found from moss, litter, soil, dung, and on plants (Evans and Hyatt 1960).

Melichares sp.

Some mites of this genus are associated with tyroglyphids in dried fruit (Evans 1958) and with bark beetles (McGraw and Farrier 1969).

Protogamasellus massula (Athias-Henriot)

This species has been collected in forests of _Quercus suber_ Linn. in Algeria (Athias-Henriot 1961). Muma et al. (1975) recorded specimens near this species from citrus litter in Florida.

Protogamasellus primitivus Karg

Muma et al. (1975) recorded this species from citrus litter in Florida. Hurlbutt (1971) recorded a subspecies, _P. primitivus similis_ Genis, Loot and Ryke in Tanzania, from under _Lantana_ bushes, from soil, leaf mold and litter.

Family Macronyssidae

Ornithonyssus sp.

Many mites of this genus are among the most important acarine parasites of mammals and birds. *O. bacoti* (Hirst) readily attacks man and has been implicated as a disease transmitter; it also acts as the vector of filarial worm in cotton rats. *O. bursa* (Berl.) and *O. sylviarum* (Canestrini and Fanzago) may become so abundant in bird nests that they kill the young birds by exanguination (Strandtmann and Wharton 1958).

Family Rhodacaridae

The Rhodacaridae is a group of mainly free-living predatory mites occurring in ground habitats. Species of *Rhodacarus* are found in plant litter and soil. *Rhodacarellus* species are also found in plant litter and soil, particularly deeper layers below three inches. *Gamasiphis* species are found in moss, plant litter and upper soil layers (Lee 1970). Muma et al. (1975) recorded three species of *Rhodacarus* and *Rhodacarellus* associated with Florida Citrus.

Rhodacarus near *denticulatus* Berl.

Athias-Henriot (1961) recorded *R. denticulatus* in soil from garden and orchard in Algeria.

Family Parasitidae

Evans (1957) regards this family as the most common and widely distributed of the parasitoids found in litter and humus. Immature stages are commonly found phoretic on beetles and other insects. Muma et al. (1975) found five species of *Parasitus* associated with citrus in Florida. C. Cruz and H. T. Streu (unpublished manuscript) collected a *Parasitus* species from pitfall traps and soil cores from turfgrass in New Jersey. It was observed to feed on the early instars of the hairy chinch bug, *Blissus leucopterus hirtus*, and also on *Proisotoma* sp. and *Entomobrya marginata* Tullberg, but not on chinch bug eggs.

Family Polyaspidae

Polyaspis sp.

Nymphs of some species are phoretic on blattids, passalids, and other insects (Johnston 1961).

Family Podocinidae

Podocinum jamaicense Evans and Hyatt

This mite has been collected from damp woody earth in Jamaica, in soil on bromeliad imported from Peru, on oak at Vero Beach, Florida, and on orchid plants imported from Mexico (DeLeon 1964, Evans and Hyatt 1957).

Family Veigaiidae

Gamasolaelaps subcorticalis McGraw and Farrier

This mite has been recorded from bark-beetle-killed Pinus taeda Linn. in Virginia, from under bark of Pinus engelmannii Carriere infested with Ips lecontei Swaine in Mexico, and in association with Dendroctonus frontalis Zimmerman, Ips avulsus (Eichhoff), I. calligraphus (Germar) attacking Pinus taeda in Louisiana and Mississippi (McGraw and Farrier 1969).

Family Parantennulidae

Micromegistus bakeri Tragardh

Nickel and Elzinga (1970) found this mite on three carabids: Scarites subterraneus Fabricius, Evarthrus sodalis colossus LeConte, and Patrobus longicornis (Say). S. subterraneus had 46.4% incidence of infestation. The female is viviparous and all stages of the mite life cycle occur on its host. M. bakeri is not parasitic, but is a commensal feeding on organic debris such as food remnants of the host. Its diet may be supplemented by feeding on the host's external secretions without measurable injury to the beetle.

Family Cercomegistidae

Cercomegistid mites are usually predators of various insects, especially the beetles (Camin and Gorirossi

1955). Known species of the genus *Cercomegistus* are *C. bruckianus* Berl., found under barks, *C. simplicior* Vitzthum, collected from dead fern stems, and *C. evonicus* Kinn, occurred under the bark of *Pinus monophylla* Torr. and Frém. killed by *Ips confusus* (Lec.) and in galleries of the beetle (Kinn 1967). The *Cercomegistus* sp. collected in this survey does not belong to the above three species, although it is closer in external morphology to *C. bruckianus* than to the other two species.

Family Uropodidae

Oplitis communis Hunter and Farrier

This mite has been found in nests of *Solenopsis invicta* Buren and *S. geminata* (Fabricius), also in moss and leaf litter. It has been recorded from North and South Carolina and Florida (Hunter and Farrier 1975).

CONCLUSION

This research, which was one of the first detailed analyses of a suborder of mites from a specific ecological habitat, has indicated the following:

1. There appears to be considerable species diversity in the seemingly homogeneous habitat of turfgrass. This is shown by the numbers of taxa in the mite suborders: 14 families and 72 species in Mesostigmata; 13 superfamilies in Cryptostigmata; two families in Astigmata; and at least 18 families in Prostigmata.
2. The most numerous species found were:

    Hypoaspis near *claviger*

    Oplitis communis

    Pseudoparasitus stigmatus

    Leonardiella sp.

    Macrocheles near *insignitis*

    Ololaelaps sp.

    Although these mites represent different families and genera, they would appear to be likely candidates for indicator species in turfgrass situations. Representatives of the same genera have been reported all over the world in soil and litter. The verification of these six species as biological indicators would be of major value in future research and is an area that should be pursued.

3. I believe sufficient information has been obtained so that future research in turfgrass areas where pesticides have been used can be compared with this work in an evaluation of pesticide effects on soil mite populations. Ultimately, these various threads of research, when drawn together, will enable us to better understand the effects of repeated pesticide use in the environment, and will offer new avenues for intelligently redesigning current agricultural practices in order to live more harmoniously with nature.
4. The majority of the common mites tend to have a fall and winter population peak in south Florida. This would suggest that collection of data might be intensified in this period to get sufficient numbers for quantitative population density studies. It would also suggest that when studying a turf area which had been heavily treated with pesticides and where mite numbers had been reduced, that these seasons would be the best for sample collections for any indications of effects on general soil mite populations.
5. The study indicated how little is known of soil mite fauna since the majority of species collected had never been described previously.

6. Diversity of mesostigmatid mites is greatest in St. Augustinegrass.
7. In the family Phytoseiidae, only the subfamily Amblyseiinae is found associated with turfgrasses. This supports Muma's (1968) theory that in some restricted habitats, such as Florida sand-pine litter,only one subfamily of Phytoseiidae may be found.
8. Statistical analysis in this study apparently provides no reliable indication of whether a mite species is associated with ants. A more detailed biological study is needed to obtain this type of information.
9. When estimating population trends with samples obtained from Berlese funnels, greater confidence can be placed on drop samples than on slide mount samples, the latter being subject to more human error and tending to show excessively high proportion of Mesostigmata.

Table 1. Mean Numbers of Mites and Major Groups of Insects from Berlese Samples* Collected from Each of Three Species of Turfgrass in Ft. Lauderdale, Florida.

Grass species	Mean Number of Specimens				
	Mites	Collembola	Ants	Scales	Thrips
St. Augustine	3003.4b**	853.7a	97.6a	78.9a	19.5a
Bahia	5140.7a	382.0b	135.8a	144.9a	27.3a
Bermuda	3038.1b	859.9a	97.9a	164.6a	3.0b

*Three 20.3 cm-diameter, 10 cm-deep plug samples of grass, thatch, and soil were taken every other week from each grass.

**Means followed by same letter within a column do not differ significantly (1%) by Least Significant Difference test.

Table 2. Mean Numbers of Four Mite Suborders from Slide Samples* Collected from Each of Three Species of Turfgrass in Ft. Lauderdale, Florida.

	Mean Number of Mites				
Grass species	Crypto-stigmata	Prostig-mata	Astig-mata	Meso-stigmata	TOTAL
St. Augustine	33.0a**	24.2a	0.6a	27.1a	85.0
Bahia	37.9ab	26.0a	0.8a	23.6ab	88.3
Bermuda	41.1b	22.7a	1.8a	20.7b	86.4

*Three samples were taken every other week from each grass.

**Means followed by same letter within a column do not differ significantly (1%) by Least Significant Difference test.

Table 3. Percentages of Four Suborders of Mites from Slide Samples* Collected from Three Species of South Florida Turfgrass, Compared by Month.

Month		Percent of Total Mites			
		Cryptostigmata	Prostigmata	Astigmata	Mesostigmata
	JUN	40.18	29.45	1.23	29.14
Summer	JUL	51.31	13.28	1.49	33.93
	AUG	43.86	25.08	1.46	29.59
	SPT	57.27	17.99	2.61	22.17
Fall	OCT	40.51	32.32	1.24	25.93
	NOV	50.00	20.10	5.99	23.89
	DEC	43.50	22.52	1.52	32.46
Winter	JAN	47.12	25.61	0.69	26.58
	FEB	43.74	19.56	0.47	36.23
	MAR	35.99	32.46	0.58	30.96
Spring	APR	37.80	36.66	0.48	25.06
	MAY	43.46	33.69	0.58	22.27
	JUN	39.32	48.74	0.24	11.70

*Three samples were taken every other week from each grass.

Table 4. Percentages of Four Suborders of Mites from Slide Samples* Collected from Three Species of South Florida Turfgrass, Compared by Grass Species.

Grass Species	Percent of Total Mites			
	Cryptostigmata	Prostigmata	Astigmata	Mesostigmata
St. Augustine	38.87	28.52	0.72	31.89
Bahia	42.98	29.45	0.88	26.69
Bermuda	47.59	26.32	2.14	23.95

*Three samples were taken every other week from each grass.

Table 5. Families and Species of Suborder Mesostigmata Found in Slide Samples Collected Every Other Week from Three Plots Each of Three Species of Turfgrass in Ft. Lauderdale, Florida. Included Are Total Numbers of Specimens Found, Occurrances in Each Species of Turfgrass, Seasonal Occurrances, and Occurrances of Sexes.

Family		Grass Species			Seasons*				**	
Genus and Species	TOTAL	St. Aug.	Bahia	Bermuda	Summer	Fall	Winter	Spring	Female	Male
Macrochelidae										
<u>Macrocheles</u> near <u>insignitis</u> Berl.	287	120	90	77	45	111	93	38	279	8
<u>M.</u> near <u>mammifer</u> (Berl.)	140	0	4	136	22	50	38	30	109	21
<u>M.</u> <u>muscaedomesticae</u> (Scopoli)	99	0	6	93	2	27	49	21	99	0
<u>Glyptholaspis</u> <u>americana</u> (Berl.)	38	10	3	25	1	4	23	10	31	7
<u>Holostaspella</u> <u>bifoliata</u> (Tragardh)	1	0	0	1	0	0	1	0	1	0
Phytoseiidae										
<u>Proprioseiopsis</u> <u>gracilisetae</u> (Muma)	58	40	9	9	4	39	14	1	35	22
<u>P.</u> <u>mexicanus</u> (Garman)	13	4	3	6	0	7	2	4	13	0++
<u>P.</u> n. sp.	10	3	2	5	0	6	2	2	10	0++
<u>P.</u> <u>sarraceniae</u> (Muma)	8	3	1	4	0	2	5	1	8	0++
<u>P.</u> <u>citri</u> (Muma)	7	2	2	3	0	5	2	0	7	0++
<u>P.</u> <u>cannaensis</u> (Muma)	7	2	2	3	0	6	0	1	7	0++
<u>P.</u> <u>rotundus</u> (Muma)	5	5	0	0	0	1	3	1	5	0++
<u>P.</u> <u>asetus</u> (Chant)	3	3	0	0	1	1	0	1	3	0++
<u>Neoseiulus</u> <u>planatus</u> (Muma)	13	0	12	1	3	4	2	4	13	0
<u>N.</u> <u>paspalivorus</u> (De Leon)	3	0	3	0	0	1	1	1	3	0
<u>N.</u> <u>marinellus</u> (Muma)	0+	0	0	0	0	0	0	0	1	0
<u>Chelaseius</u> <u>floridanus</u> (Muma)	7	2	3	2	1	3	1	2	7	0
<u>Amblyseius</u> <u>rhabdus</u> Denmark	6	3	1	2	0	0	1	5	6	0
<u>Typhlodromips</u> <u>digitulus</u> Denmark	1	0	1	0	0	0	0	1	1	0
Laelapidae										
<u>Hypoaspis</u> near <u>claviger</u> (Berl.)	764	153	421	190	151	238	241	134	623	81
<u>H.</u> near <u>vacua</u> (Michael) sp. 1	71	28	13	30	24	22	14	11	51	11

H. near vacua (Michael) sp. 2	7	3	0	4	3	3	0	1	7	0
H. near praesternalis Willmann sp. 1	140	5	80	55	27	48	48	17	128	12
H. near praesternalis Willmann sp. 2	4	0	3	1	0	3	0	1	4	0
H. near praesternalis Willmann sp. 3	6	4	0	2	1	3	2	0	6	0
H. near aculeifer (Canestrini)	108	106	1	1	15	33	36	24	82	25
H. (Laelaspis) near piloscutuli (Hunter)	5	0	0	5	0	0	0	5	5	0
H. (Laelaspis) sp. 1	1	1	0	0	0	1	0	0	1	0
H. queenslandicus (Womersley)	11	11	0	0	3	3	1	4	9	1
H. sp. 2	3	0	3	0	0	0	0	3	3	0
H. sp. 3	1	0	1	0	0	0	1	0	1	0
H. sp. 4	1	0	1	0	0	1	0	0	1	0
Androlaelaps sp.	97	3	94	0	21	25	28	23	89	5
Pseudoparasitus stigmatus (Fox)	321	245	71	5	36	93	120	72	264	55
Ololaelaps sp.	274	76	10	188	33	84	104	53	180	94
Macronyssidae										
Ornithonyssus sp.	1	0	0	1	0	0	0	1	1	0
Ascidae										
Asca quinquesetosa Wharton	104	5	51	48	13	21	38	32	93	11
A. garmani Hurlbutt	109	35	54	20	4	44	49	12	109	0
A. brachychaeta Hurlbutt	2	1	1	0	1	0	0	1	2	0
Lasioseius near youcefi Athias-Henriot	121	30	43	48	7	48	47	19	112	4
L. scapulatus Kennett	18	17	1	0	1	8	6	3	18	0
Antennoseius sp.	30	30	0	0	2	14	10	4	18	11
Proctolaelaps sp.	18	10	8	0	5	1	8	4	18	0
Cheiroseius cassiteridum Evans and Hyatt	53	12	1	40	6	4	23	20	53	0
C. sp.	23	0	17	6	0	10	10	3	23	0
Melichares sp.	97	71	16	10	3	22	61	11	97	0
Ascidae sp.	1	1	0	0	0	1	0	0	1	0
Ascidae sp.	14	14	0	0	4	3	3	4	14	0
Protogamasellus massula (Athias-Henriot)	32	23	9	0	3	12	7	10	32	0

Table 5. Continued.

Family Genus and Species	TOTAL	Grass Species St. Aug.	 Bahia	 Bermuda	Seasons* Summer	 Fall	 Winter	 Spring	** Female	 Male
_P._ _primitivus_ Karg	43	26	10	7	8	8	9	18	43	0
_P._ sp.	10	0	5	5	4	3	3	0	10	0
Rhodacaridae										
Rhodacarus near _denticulatus_ Berl.	32	23	1	8	9	8	1	14	30	1
Gamasiphis sp. 1	80	73	7	0	21	18	22	19	49	31
_G._ sp. 2	94	68	26	0	12	44	26	12	68	26
Rhodacarellus sp. 1	42	23	7	12	6	13	5	18	42	0
_R._ sp. 2	2	0	1	1	0	1	1	0	2	0
_R._ sp. 3	1	0	1	0	0	1	0	0	1	0
_R._ sp. 4	1	1	0	0	0	0	1	0	1	0
Parasitidae										
Parasitus sp. 1	29	28	1	0	0	4	22	3	10	12
_P._ sp. 2	8	0	0	8	0	8	0	0	8	0
Polyaspidae										
Polyaspis n. sp.	40	40	0	0	2	7	14	17	15	16
Podocinidae										
Podocinum _jamaicense_ Evans and Hyatt	2	2	0	0	0	0	2	0	2	0
Veigaiidae										
Gamasolaelaps _subcorticalis_ McGraw and Farrier	4	0	0	4	0	3	1	0	3	1
Parantennulidae										
Micromegistus _bakeri_ Tragardh	13	13	0	0	0	9	4	0	5	6

Cercomegistidae										
Cercomegistus n. sp. (near *bruckianus* Berl.)	1	0	1	0	0	0	0	1	1	0
Eutrachytidae										
Leonardiella sp.	298	33	182	83	34	68	76	120	136	128
Eutrachytes sp.	48	46	0	2	12	3	10	23	28	16
Uropodidae										
Oplitis communis Hunter and Farrier	369	143	160	66	58	116	96	99	271	78
Uropoda sp.	28	0	0	28	0	6	21	1	9	17
Trachyuropoda sp.	50	4	1	45	16	23	9	2	30	23
Trachyuropodini sp. 1	14	0	11	3	0	3	5	6	8	4
Trachyuropodini sp. 2	8	2	4	2	4	1	2	1	8	0

*Spring = April, May, June; Summer = July, August, September; Fall = October, November, December; Winter = January, February, March.

**Discrepencies between total mite numbers and sums of the two sexes are due to the presence of nymphal specimens.

+Only one specimen collected in preliminary survey.

++Several Male specimens of *Propioseiopsis*, not *p. gracilisetae*, were collected but not identified to species.

Table 6. Superfamilies and Families of Mites in the Suborders Cryptostigmata, Prostigmata, and Astigmata Found from Slide Samples Collected from three Species of Turfgrass in Ft. Lauderdale, Florida.

Families of Astigmata	Families of Prostigmata	Superfamilies of Cryptostigmata
Acaridae	Bdellidae	Ameronothroidea
Anoetidae	Calyptostomidae	Carabodoidea
	Cryptognathidae	Ceratozetoidea
	Cunaxidae	Damaeoidea
	Ereynetidae	Galumnoidea
	Eriophyidae	Hypochthonoidea
	Erythraeidae	Liacaroidea
	Eupodidae	Nothroidea
	Lordalychidae	Oppioidea
	Pachygnathidae	Oribatelloidea
	Paratydeidae	Pelopoidea
	Pyemotidae	Perlohmannoidea
	Rhagidiidae	Phthiracaroidea
	Scutacaridae	
	Stigmaeidae	
	Tarsonemidae	
	Tetranechidae	
	Tydeidae	
	(4 spp. of Hydrachnellae)	

Table 7. Mean Numbers of Major Families of Mesostigmata from Slide Samples* Collected from Each of Three Species of Turfgrass in Ft. Lauderdale, Florida.

	Mean Number of Mites						
Grass species	Macrochelidae	Laelapidae	Phytoseiidae	Ascidae	Rhodacaridae	Uropodidae	Eutrachytidae
St. Augustine	2.1a**	9.9a	1.6a	4.7a	2.9a	2.3a	1.2a
Bahia	1.6a	10.7a	0.6a	3.8a	0.6b	2.7a	2.8b
Bermuda	5.2b	7.2b	0.6a	2.9a	0.3b	2.8a	1.3a

*Three samples were taken every other week from each grass.

**Means followed by same letters within a column do not differ significantly (5%) by Least Significant Difference test.

Table 8. Mean Numbers of Major Genera and Species of Mesostigmata from Slide Samples* Collected from Each of Three Species of Turfgrass in Ft. Lauderdale, Florida.

	Mean Number of Mites				
Grass species	*Proprioseiopsis* spp.	*Hypoaspis* spp.	*Macrocheles* spp.	*Asca* spp.	*Hypoaspis* near *claviger*
St. Augustine	1.5a**	4.8a	1.9a	0.6a	3.4a
Bahia	0.3a	8.0b	1.5a	1.5b	6.5b
Bermuda	0.4a	4.3a	4.8b	1.0ab	2.9a

	Pseudoparasitus stigmatus	*Ololaelaps* sp.	*Macrocheles* near *insignitis*	*Leonardiella* sp.	*Oplitis communis*
St. Augustine	3.8a	1.2b	1.9a	0.5a	2.2a
Bahia	1.1b	0.2c	1.4a	2.8b	2.4a
Bermuda	0.1c	2.8a	1.4a	1.3a	1.0b

*Three samples were taken every other week from each grass.

**Means followed by same letters within a column do not differ significantly (1%) by Least Significant Different test.

Table 9. Correlation Coefficients Among Maximum Temperature, Minimum Temperature, Precipitation, and Major Arthropod Groups from Berlese Samples* Collected from Three Species of Turfgrass in Ft. Lauderdale, Florida.

	Correlation Coefficients				
	Mites	Collembola	Ants	Scales	Thrips
Maximum Temperature	-0.21	-0.30	0.03	-0.03	-0.09
Minimum Temperature	-0.25	-0.32	-0.01	-0.02	-0.10
Precipitation	-0.16	-0.11	0.02	0.14	-0.05

*Three 20.3 cm-diameter, 10 cm-deep plug samples of grass, thatch, and soil were taken every other week from each grass.

Table 10. Correlation Coefficients Among Maximum Temperature, Minimum Temperature, Precipitation, and Four Mite Suborders from Slide Samples* Collected from Three Species of Turfgrass in Ft. Lauderdale, Florida.

	Correlation Coefficients			
	Cryptostigmata	Prostigmata	Astigmata	Mesostigmata
Maximum Temperature	-0.22	0.03	-0.08	-0.33
Minimum Temperature	-0.17	-0.01	-0.03	-0.35
Precipitation	-0.05	-0.07	0.01	-0.14

*Three samples were taken every other week from each grass.

Table 11. Correlation Coefficients Among Maximum Temperature, Minimum Temperature, Precipitation, and Major Mesostigmatid Families from Slide Samples* Collected from Three Species of Turfgrass in Ft. Lauderdale, Florida.

	Correlation Coefficients						
	Macrochelidae	Laelapidae	Phytoseiidae	Ascidae	Rhodacaridae	Uropodidae	Eutrachytidae
Maximum Temperature	-0.25	-0.16	-0.23	-0.27	-0.05	-0.08	0.09
Minimum Temperature	-0.24	-0.19	-0.17	-0.29	-0.03	-0.06	0.04
Precipitation	-0.09	-0.15	0.03	-0.19	0.08	-0.06	0.06

*Three samples were taken every other week from each grass.

Table 12. Correlation Coefficients Among Maximum Temperature, Minimum Temperature, Precipitation, and Four Mite Suborders from Drop Samples* Collected from Three Species of Turfgrass in Ft. Lauderdale, Florida.

	Correlation Coefficients			
	Crypto-stigmata	Pro-stigmata	Astig-mata	Meso-stigmata
Maximum Temperature	-0.15	-0.07	-0.11	-0.09
Minimum Temperature	-0.17	-0.18	-0.04	-0.15
Precipitation	-0.11	-0.22	0.13	-0.12

*Three samples were taken every other week from each grass.

Table 13. Mean Values of Shannon-Wiener Index for Families (H_F) and Species (H_{spp}) of Mesostigmata from Slide Samples* Collected from Each of Three Species of Turfgrass in Ft. Lauderdale, Florida.

Grass species	H_F	H_{spp}
St. Augustine	0.56a**	0.80a
Bahia	0.49b	0.69b
Bermuda	0.43b	0.67b

*Three samples were taken every other week from each grass.

**Means followed by same letter within a column do not differ significantly (5%) by Least Significant Difference test.

Table 14. Mean Numbers of Four Mite Suborders from Drop Samples* Collected from Each of Three Species of South Florida Turfgrass.

	Mean Number of Mites				
Grass species	Cryptostigmata	Prostigmata	Astigmata	Mesostigmata	TOTAL
St. Augustine	10.4a**	10.8a	- a+	5.5a	26.8
Bahia	32.8c	16.4b	- a	3.8b	52.9
Bermuda	19.0b	9.2a	0.3a	3.5b	31.9

*Three samples were taken every other week from each grass.

**Means followed by same letter within a column do not differ significantly (5%) by Least Significant Difference test.

+Less than 0.1.

Table 15. Percentages of Four Suborders of Mites from Drop Samples* Collected from Three Species of South Florida Turfgrass, Compared by Month.

Month		Percent of Total Mites			
		Cryptostigmata	Prostigmata	Astigmata	Mesostigmata
	JUN	33.99	47.11	0.47	18.41
Summer	JUL	78.86	10.09	1.89	9.15
	AUG	68.73	20.44	0.36	10.47
	SPT	60.66	26.48	0.42	12.44
Fall	OCT	64.99	27.98	0.37	6.66
	NOV	50.17	36.87	0.39	12.57
	DEC	58.86	28.75	0.99	11.39
Winter	JAN	61.87	27.28	0.21	10.64
	FEB	56.18	32.65	0.05	11.13
	MAR	56.46	34.74	0.02	8.77
Spring	APR	41.73	45.67	0.00	12.60
	MAY	53.64	34.39	0.28	11.68
	JUN	58.04	30.58	0.20	11.17

*Three samples were taken every other week from each grass.

Table 16. Percentages of Four Suborders of Mites from Drop Samples* Collected from Three Species of South Florida Turfgrass, Compared by Grass Species.

	Percent of Total Mites			
Grass species	Cryptostigmata	Prostigmata	Astigmata	Mesostigmata
St. Augustine	38.63	40.53	0.22	20.62
Bahia	61.87	30.89	0.15	7.08
Bermuda	59.52	28.80	0.81	10.86

*Three samples were taken every other week from each grass.

Table 17. Correlation Coefficients of Mites and Major Insect Groups from Berlese Samples* Collected from Three Species of Turfgrass in Ft. Lauderdale, Florida.

	Correlation Coefficients			
	Mites	Collembola	Ants	Scales
Thrips	0.41	0.21	0.02	-0.04
Scales	0.08	0.01	0.16	
Ants	0.04	-0.12		
Collembola	0.18			

*Three 20.3 cm-diameter, 10 cm-deep plug samples of grass, thatch, and soil were taken every other week from each grass.

Table 18. Correlation Coefficients of Suborders of Mites from Slide Samples* Collected from Three Species of Turfgrass in Ft. Lauderdale, Florida.

	Correlation Coefficients		
	Cryptostigmata	Prostigmata	Astigmata
Mesostigmata	0.06	-0.06	-0.04
Astigmata	0.11	-0.11	
Prostigmata	0.14		

*Three samples were taken every other week from each grass.

Table 19. Correlation Coefficients of four Mite Suborders from Drop Samples* Collected from Three Species of Turfgrass in Ft. Lauderdale, Florida.

	Correlation Coefficients		
	Cryptostigmata	Prostigmata	Astigmata
Mesostigmata	0.21	0.33	0.08
Astigmata	0.13	0.02	
Prostigmata	0.47		

*Three samples were taken every other week from each grass.

Table 20. Correlation Coefficients of Major Families of Mesostigmata from Slide Samples* Collected from Three Species of Turfgrass in Ft. Lauderdale, Florida.

	Correlation Coefficients					
	Macrochelidae	Laelapidae	Phytoseiidae	Ascidae	Rhodacaridae	Uropodidae
Eutrachytidae	-0.10	0.22	-0.10	-0.13	-0.17	0.33
Uropodidae	-0.08	0.15	-0.09	0.10	0.25	
Rhodacaridae	-0.08	0.06	0.03	0.28		
Ascidae	-0.11	0.05	-0.03			
Phytoseiidae	-0.03	-0.01				
Laelapidae	0.15					

*Three samples were taken every other week from each grass.

Table 21. Correlation Coefficients of Ants from Berlese Samples* with Some Mesostigmatid Species from Slide Samples Collected from Three Species of Turfgrass in Ft. Lauderdale, Florida, and Overall Mean Numbers of These Mite Species.

Mite Species	Mean Specimen Number Per Sample	Correlation Coefficient with Ants
Hypoaspis near *claviger*	3.9	0.13
H. near *praesternalis* sp. 3	- **	0.17
H. (Laelaspis) near *piloscutuli*	-	0.22
H. (Laelaspis) sp. 1	-	0.10
Asca quinquesetosa	0.6	-0.14
Lasioseius near *youcefi*	0.6	-0.13
Cheiroseius sp.	0.1	0.14
Gamasiphis sp. 1	0.4	-0.11
Gamasiphis sp. 2	0.5	-0.14
Leonardiella sp.	1.5	0.43

*Three 20.3 cm-diameter, 10 cm-deep plug samples of grass, thatch, and soil were taken every other week from each grass.

**Less than 0.1.

Table 22. Correlation Coefficients of Mite Numbers from Berlese Samples* with Total and Suborder Mite Numbers from Drop Samples and Total Mite Numbers from Slide Samples.

		Correlation Coefficients Mites from Berlese Samples
Drop Samples	Total Mites	0.79
	Cryptostigmata	0.68
	Prostigmata	0.67
	Astigmata	0.11
	Mesostigmata	0.32
Slide Samples	Total Mites	0.12

*Three 20.3 cm-diameter, 10 cm-deep plug samples of grass, thatch, and soil were taken every other week from each grass.

Table 23. Overall Means and Percentages of Four Mite Suborders from Drop Samples* and Slide Samples Collected from Three Species of Turfgrass in Ft. Lauderdale, Florida.

	Mean Number of Mites (Percent of Total Mites)			
	Cryptostigmata	Prostigmata	Astigmata	Mesostigmata
Drop Samples	21.5 (56.16%)	12.4 (32.49%)	0.1 (0.33%)	4.2 (11.02%)
Slide Samples	37.4 (43.19%)	24.3 (28.09%)	1.1 (1.26%)	23.8 (27.45%)

*Three samples were taken every other week from each grass.

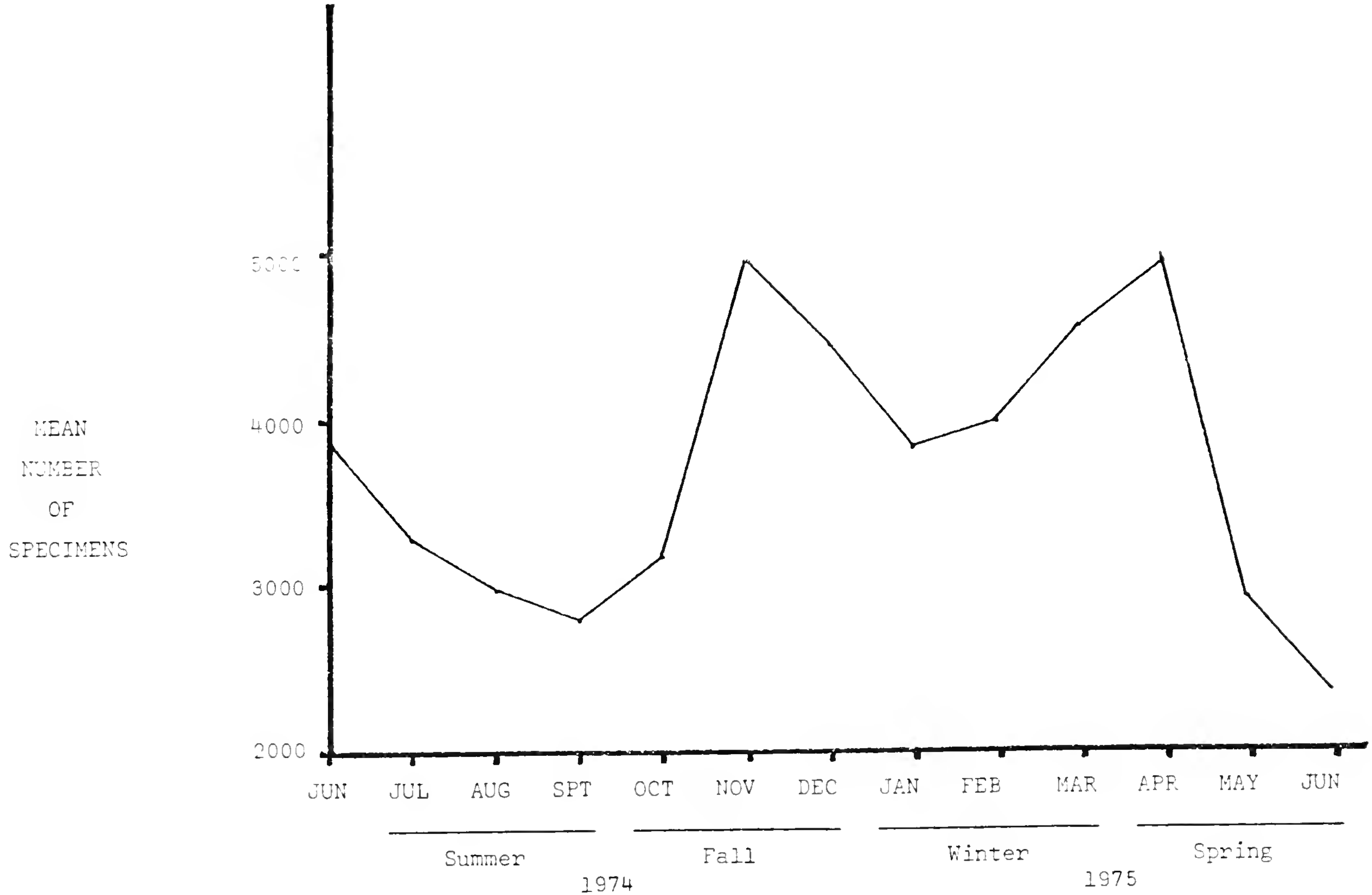


Figure 1. Monthly mean number of all mites from Berlese samples from three species of turfgrass in Ft. Lauderdale, Florida. Three 20.3 cm-diameter, 9 cm-deep core samples were taken every other week from each grass.

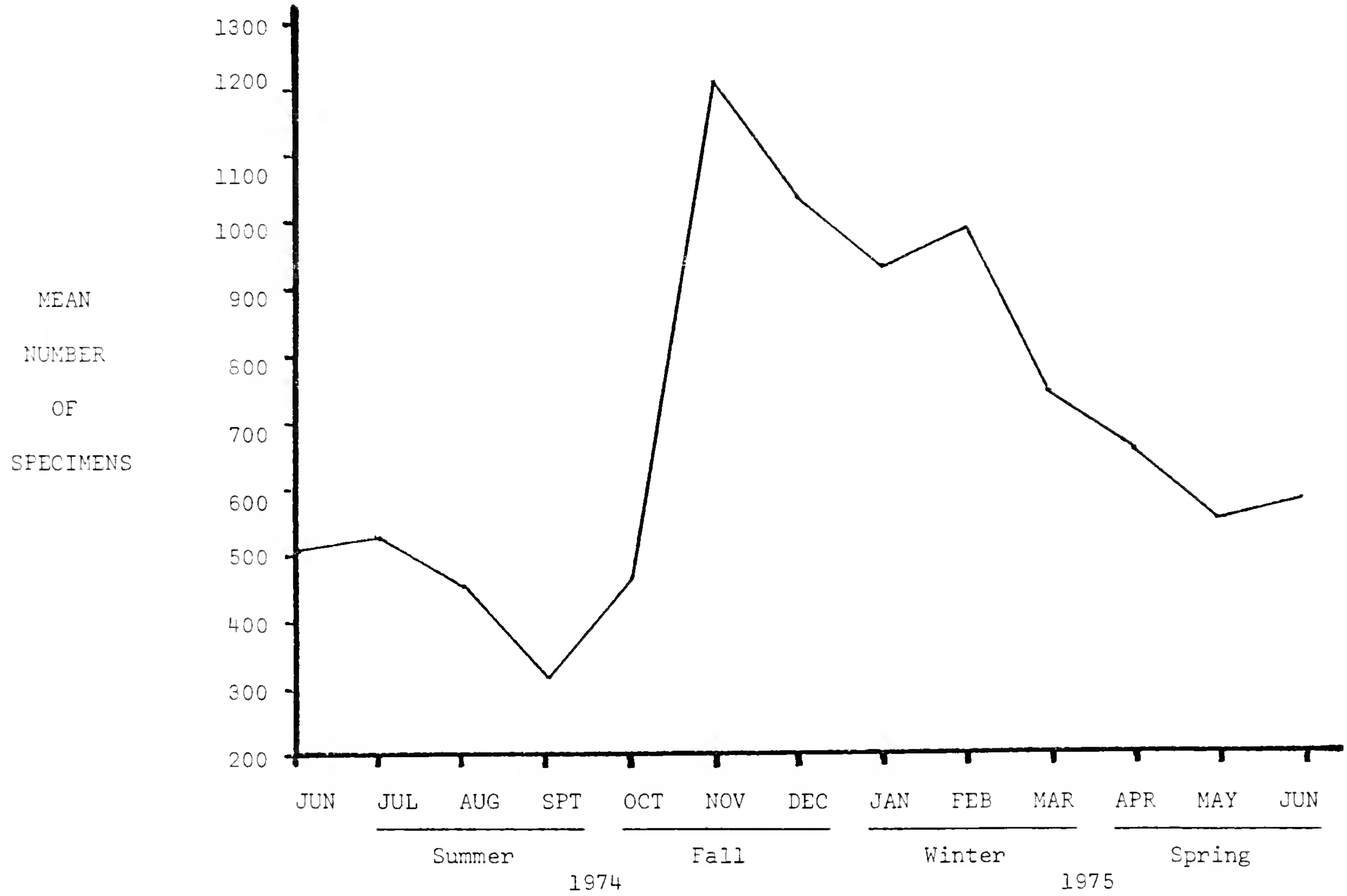


Figure 2. Monthly mean number of Collembola from Berlese samples from three species of turfgrass in Ft. Lauderdale, Florida. Three 20.3 cm-diameter, 9 cm-deep core samples were taken every other week from each grass.

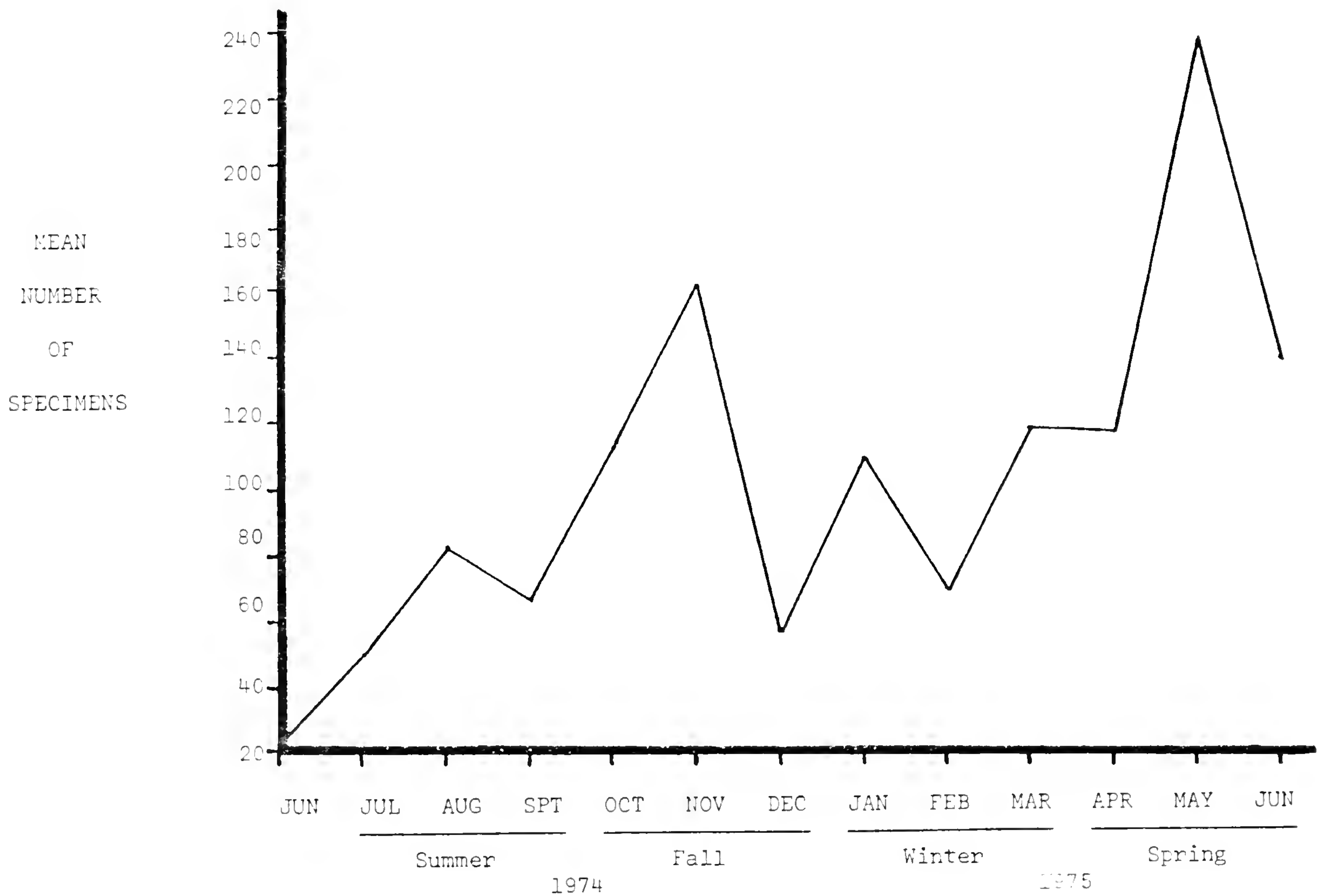


Figure 3. Monthly mean number of ants from Berlese samples from three species of turfgrass in Ft. Lauderdale, Florida. Three 20.3 cm-diameter, 9 cm-deep core samples were taken every other week from each grass.

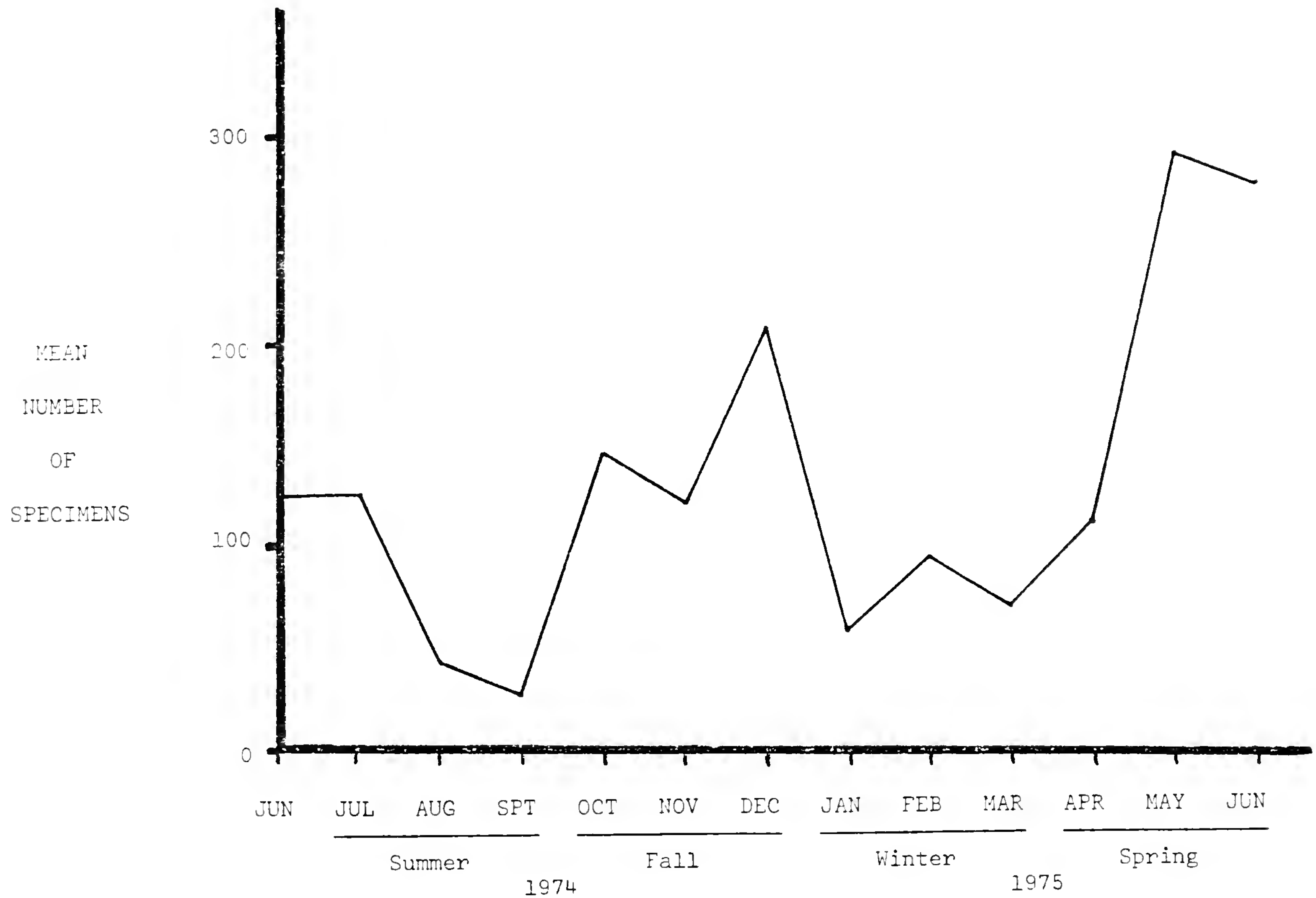


Figure 4. Monthly mean number of scales from Berlese samples from three species of turfgrass in Ft. Lauderdale, Florida. Three 20.3 cm-diameter, 9 cm-deep core samples were taken every other week from each grass.

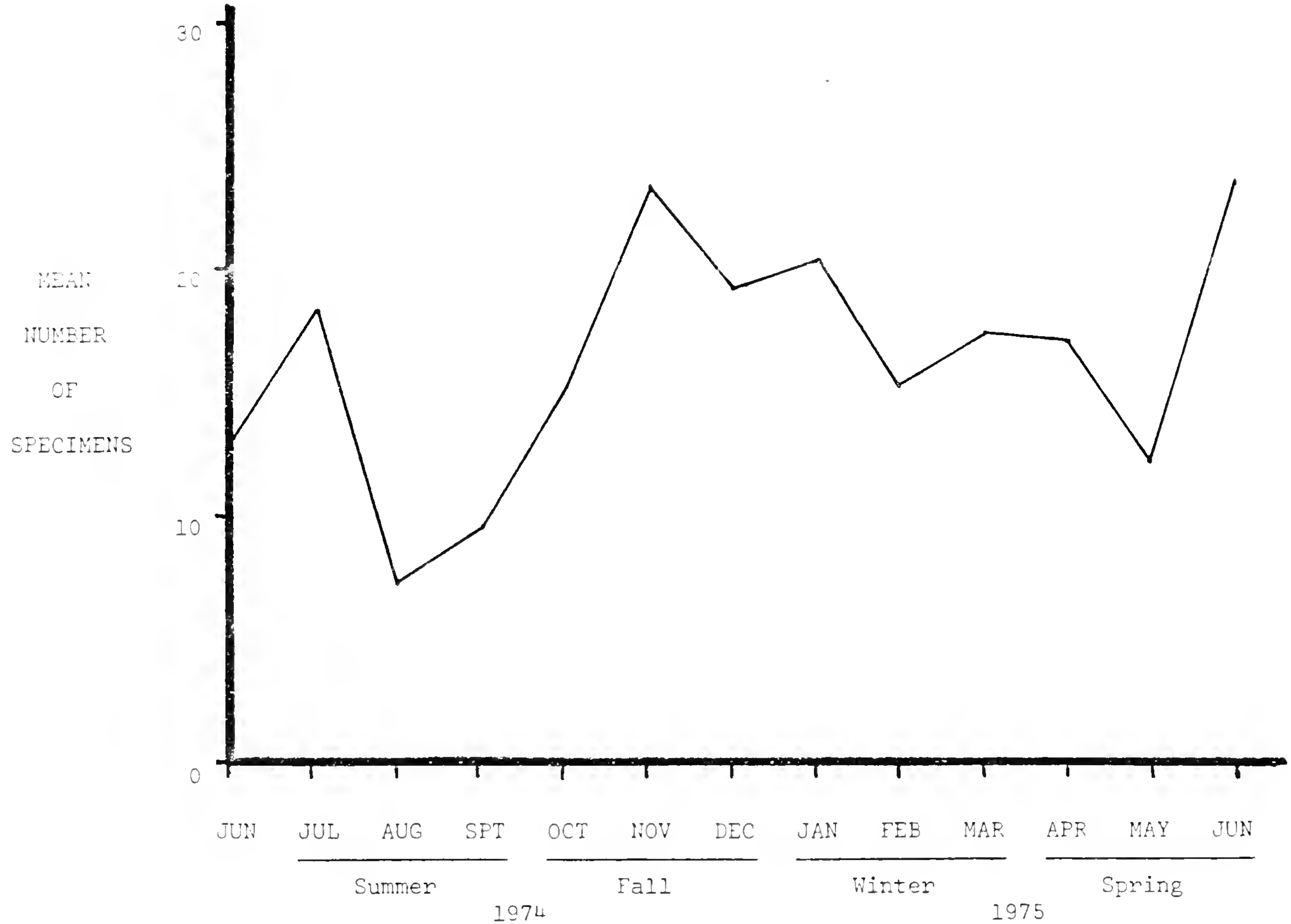


Figure 5. Monthly mean number of thrips from Berlese samples from three species of turfgrass in Ft. Lauderdale, Florida. Three 20.3 cm-diameter, 9 cm-deep core samples were taken every other week from each grass.

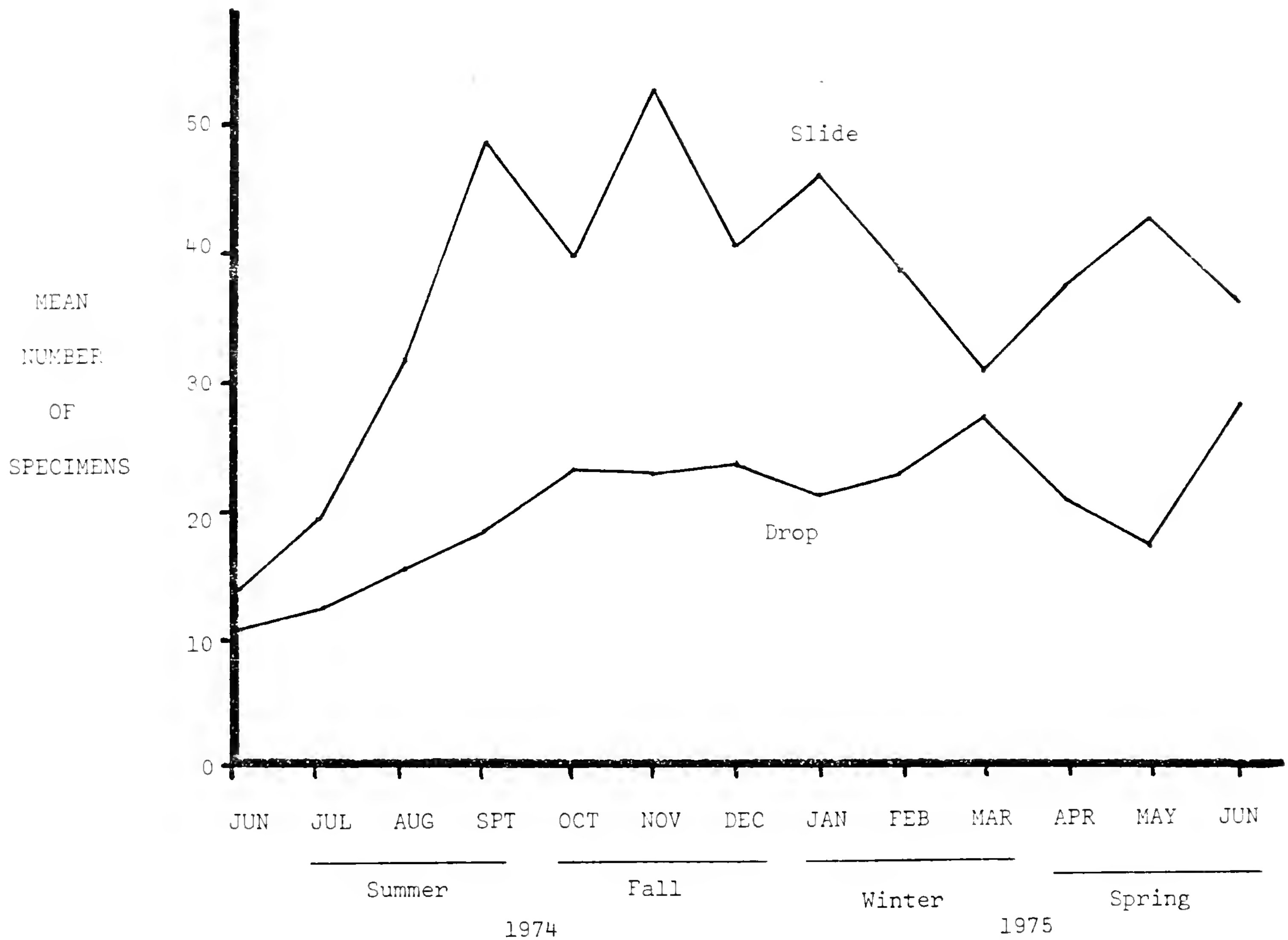


Figure 6. Monthly mean number of suborder Cryptostigmata from slide and drop samples from three species of turfgrass in Ft. Lauderdale, Florida. Three samples were taken every other week from each grass.

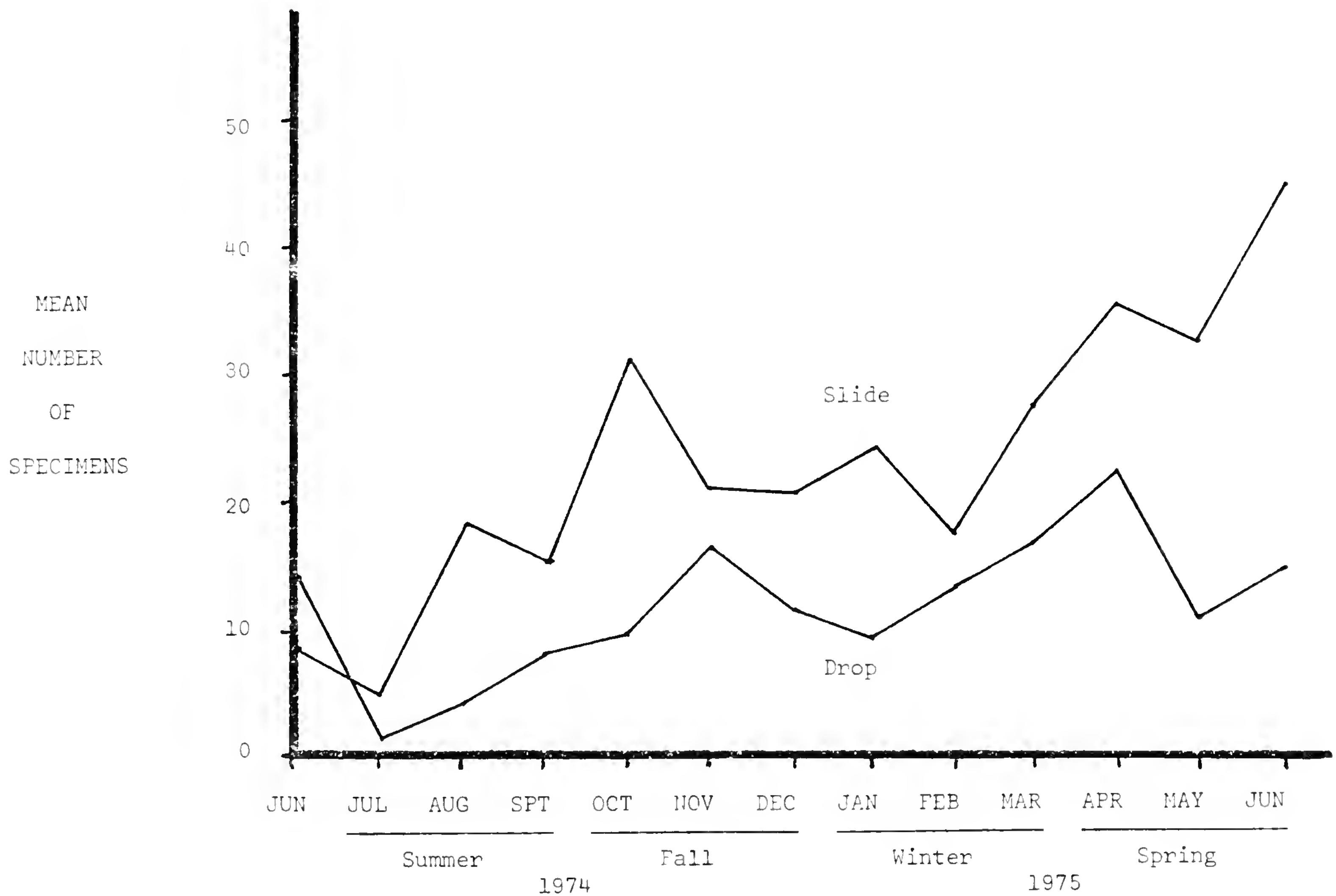


Figure 7. Monthly mean number of suborder Prostigmata from slide and drop samples from three species of turfgrass in Ft. Lauderdale, Florida. Three samples were taken every other week from each grass.

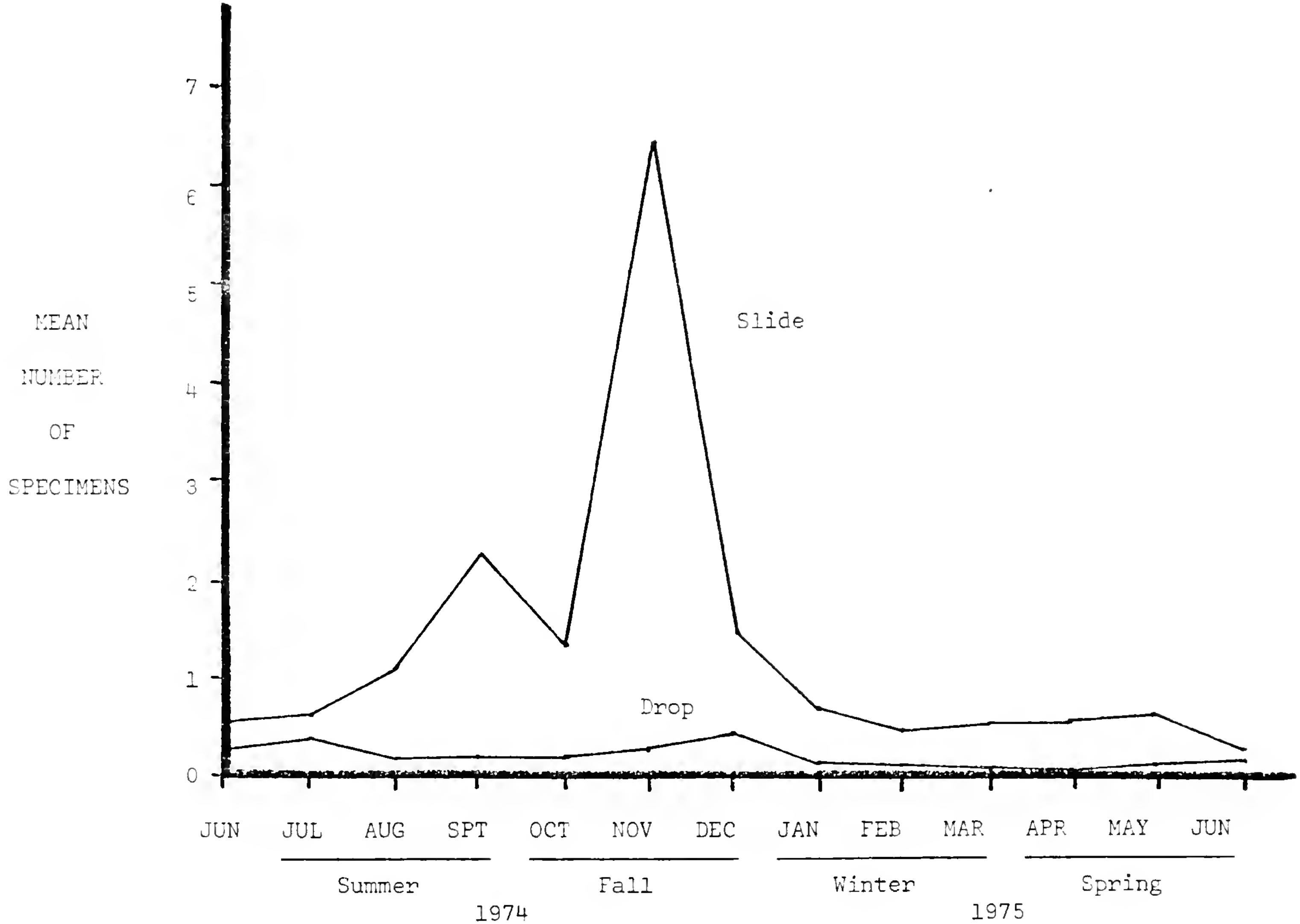


Figure 8. Monthly mean number of suborder Astigmata from slide and drop samples from three species of turfgrass in Ft. Lauderdale, Florida. Three samples were taken every other week from each grass.

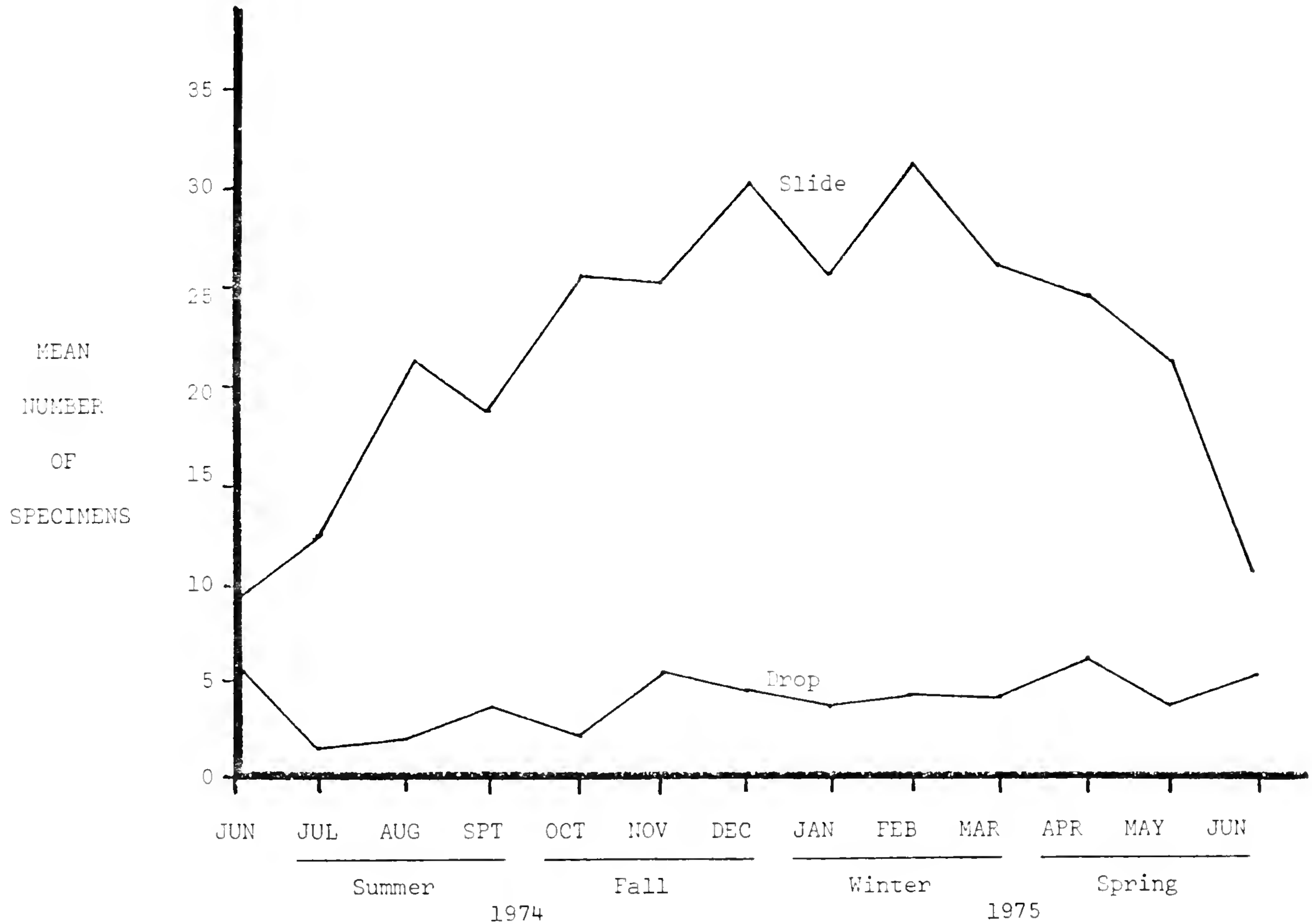


Figure 9. Monthly mean number of suborder Mesostigmata from slide and drop samples from three species of turfgrass in Ft. Lauderdale, Florida. Three samples were taken every other week from each grass.

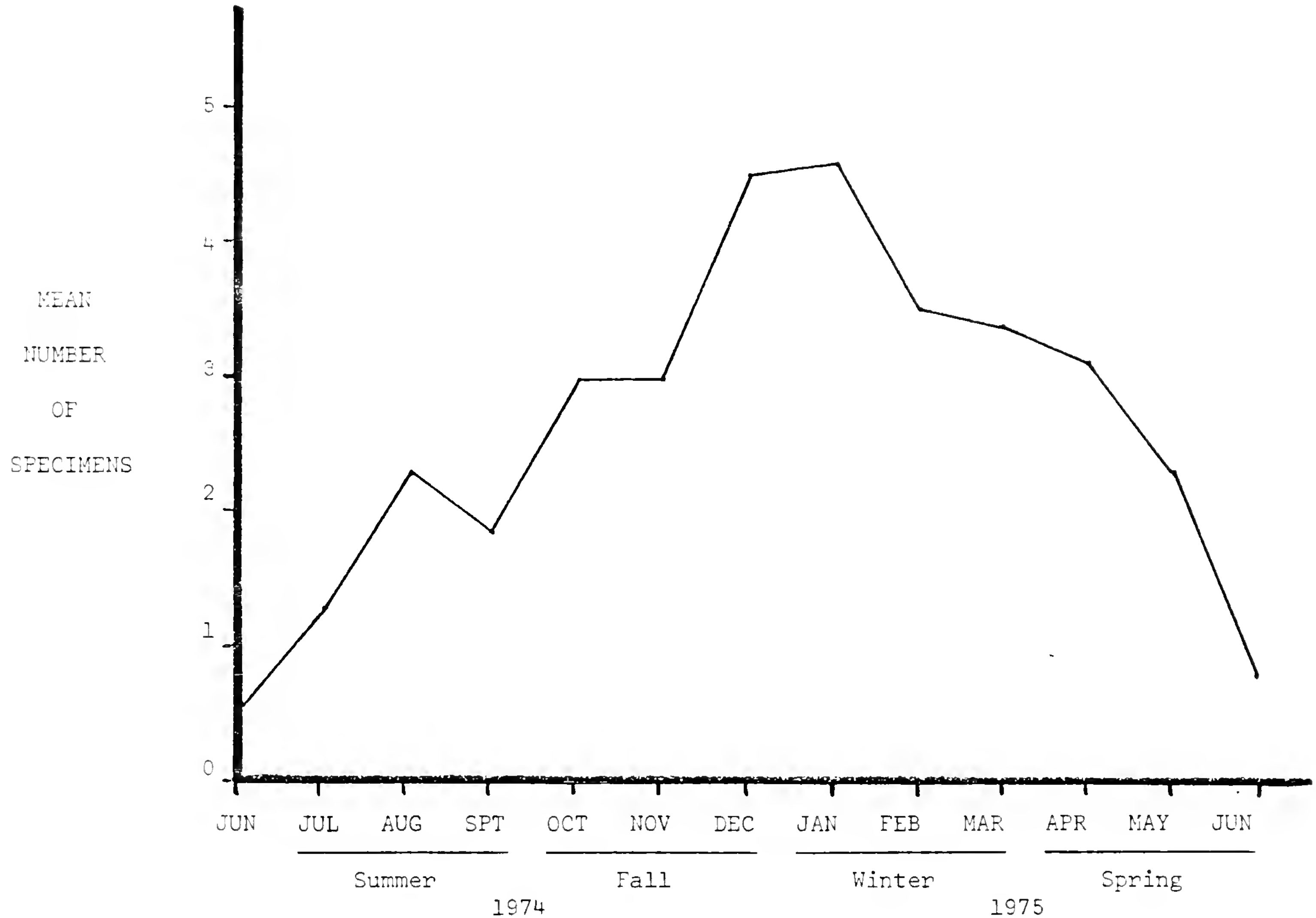


Figure 10. Monthly mean number of family Macrochelidae from three species of turfgrass in Ft. Lauderdale, Florida. Three samples were taken every other week from each grass.

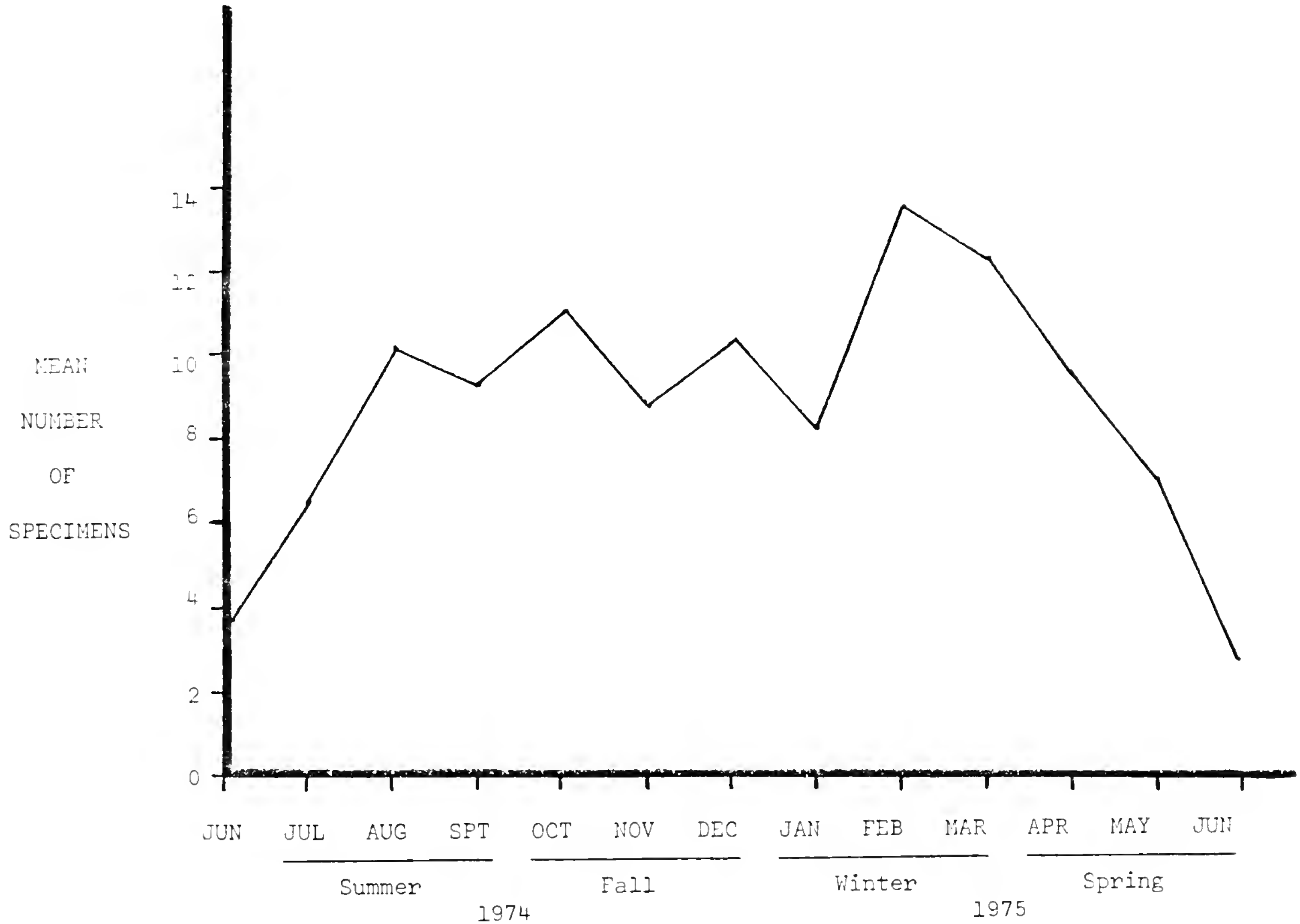


Figure 11. Monthly mean number of family Laelapidae from three species of turfgrass in Ft. Lauderdale, Florida. Three samples were taken every other week from each grass.

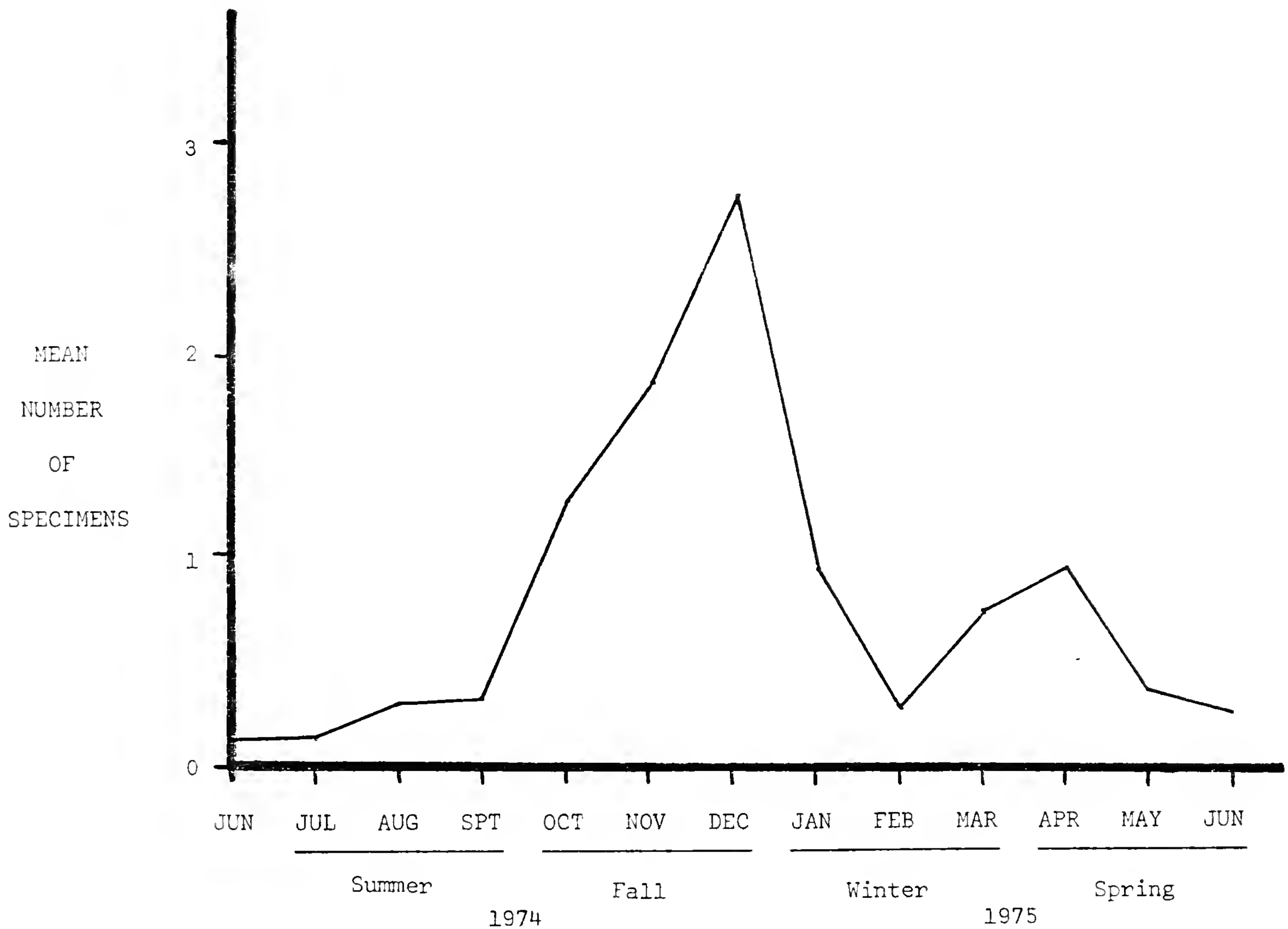


Figure 12. Monthly mean number of family Phytoseiidae from three species of turfgrass in Ft. Lauderdale, Florida. Three samples were taken every other week from each grass.

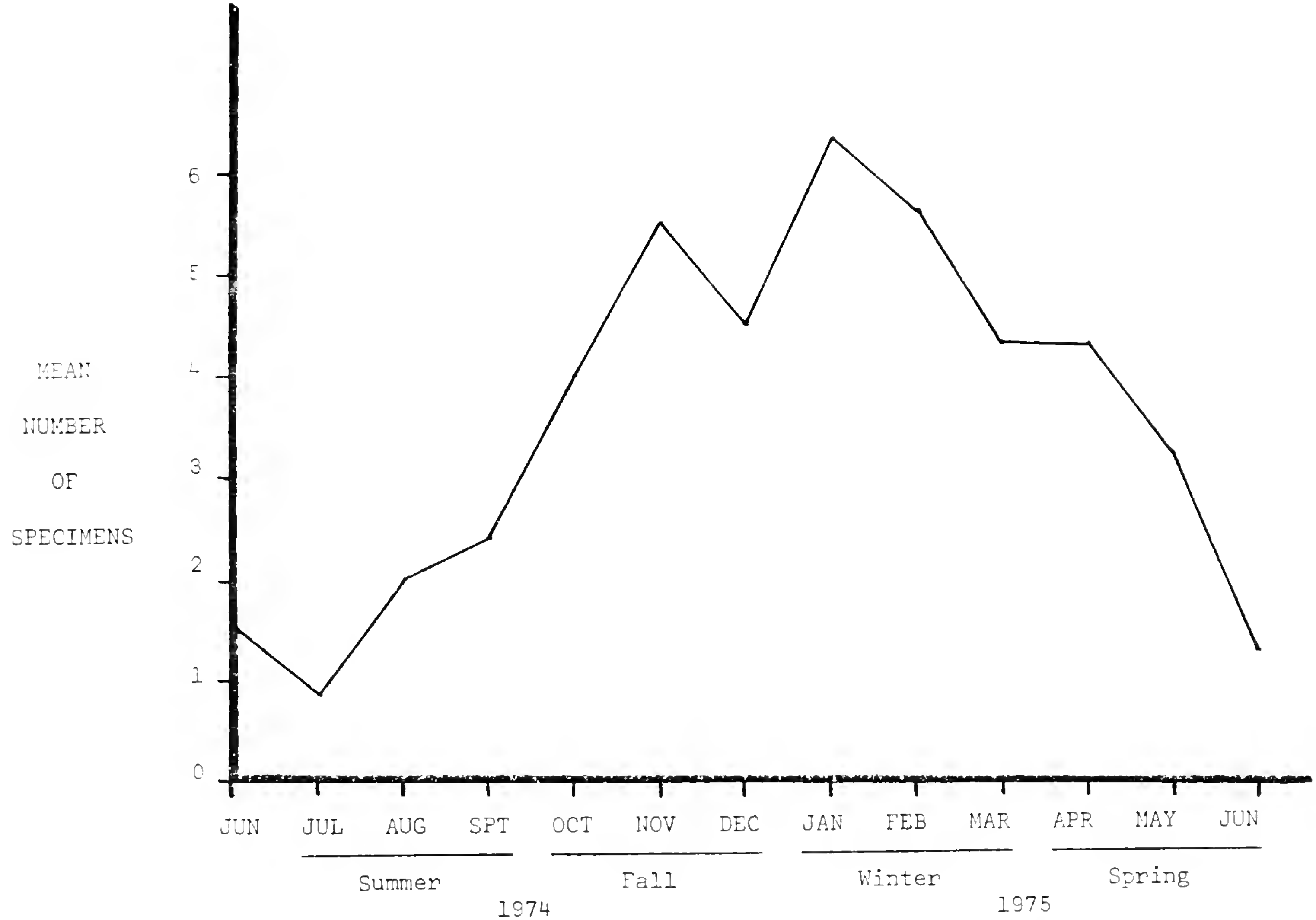


Figure 13. Monthly mean number of family Ascidae from three species of turfgrass in Ft. Lauderdale, Florida. Three samples were taken every other week from each grass.

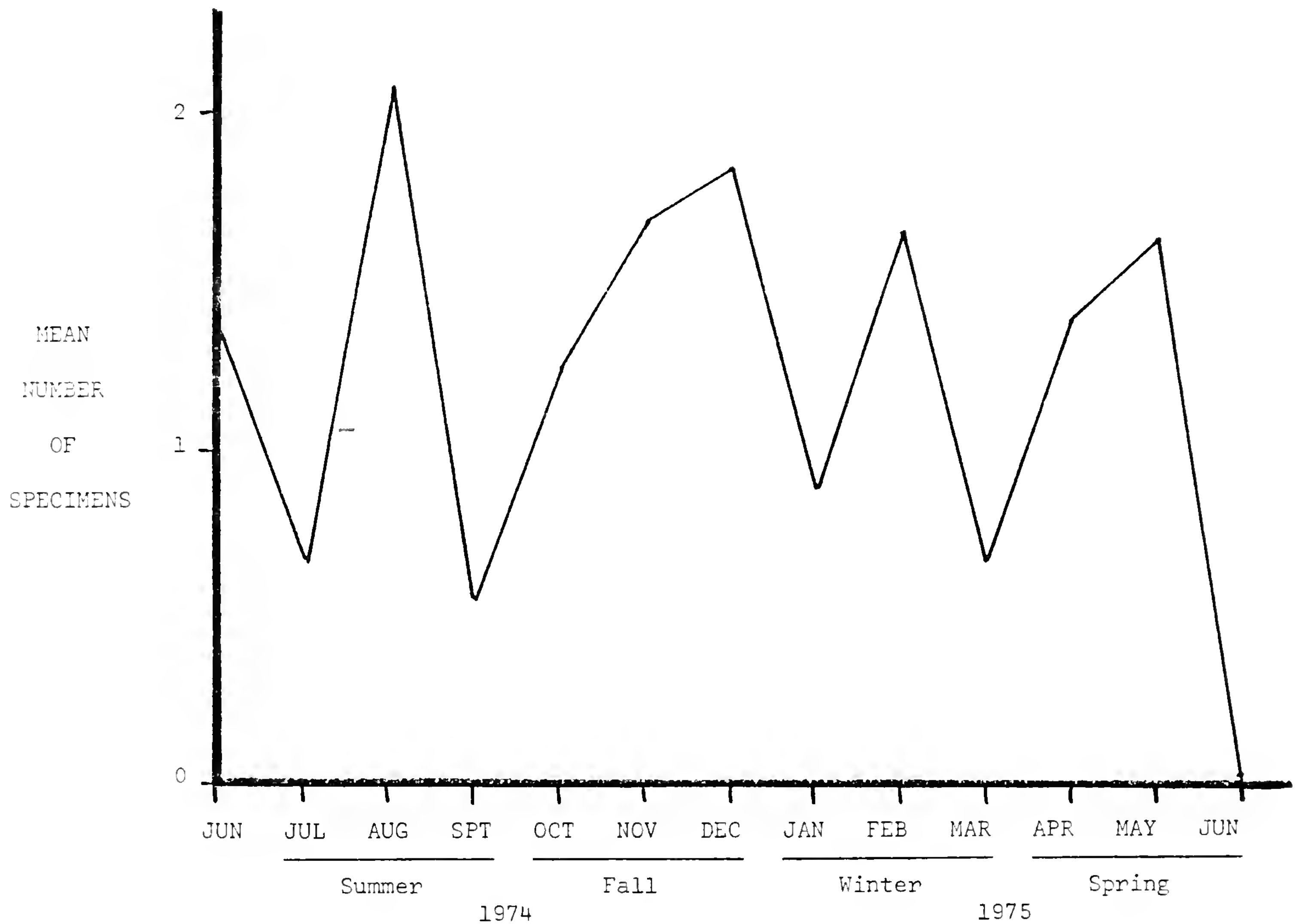


Figure 14. Monthly mean number of family Rhodacaridae from three species of turfgrass in Ft. Lauderdale, Florida. Three samples were taken every other week from each grass.

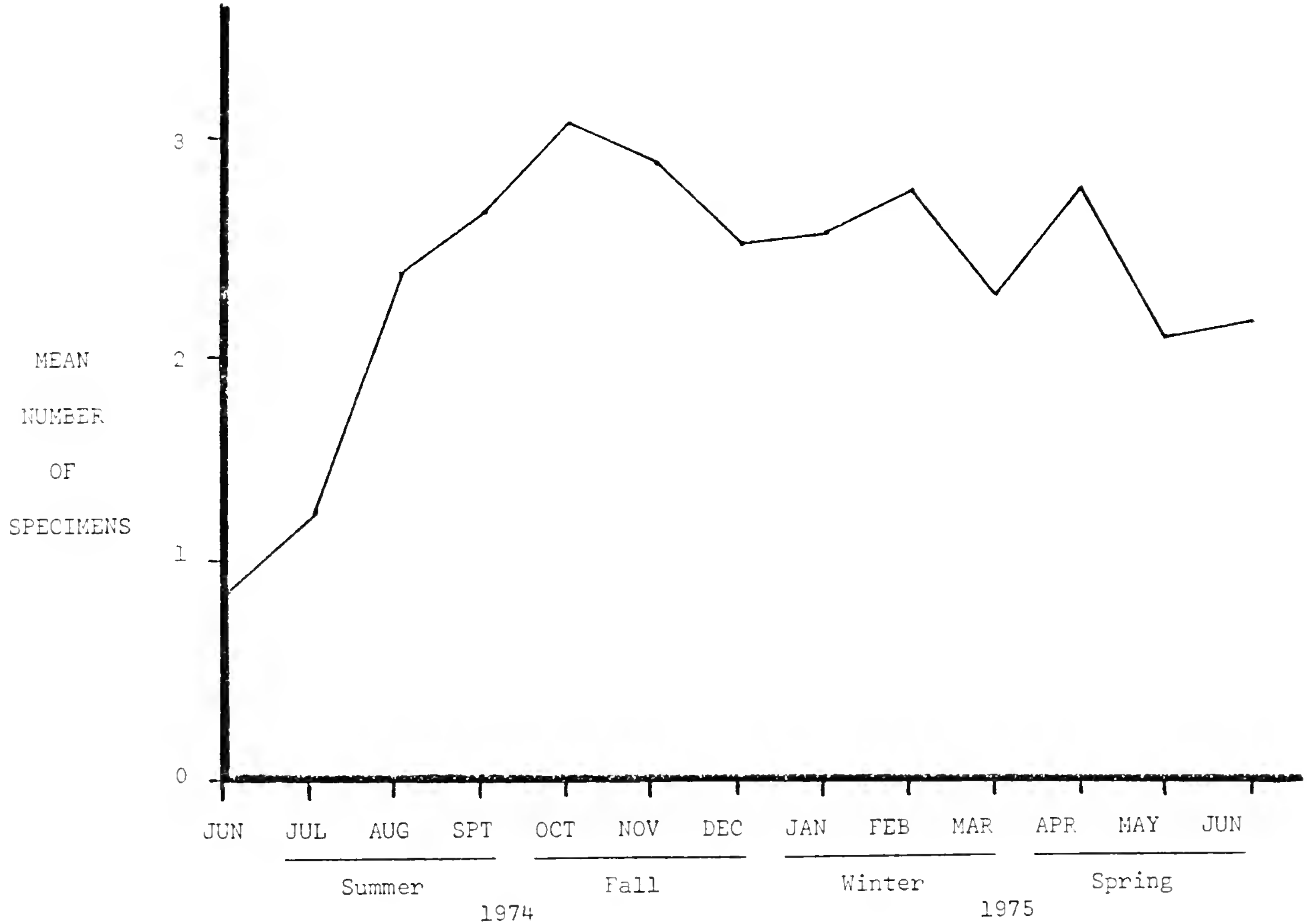


Figure 15. Monthly mean number of family Uropodidae from three species of turfgrass in Ft. Lauderdale, Florida. Three samples were taken every other week from each grass.

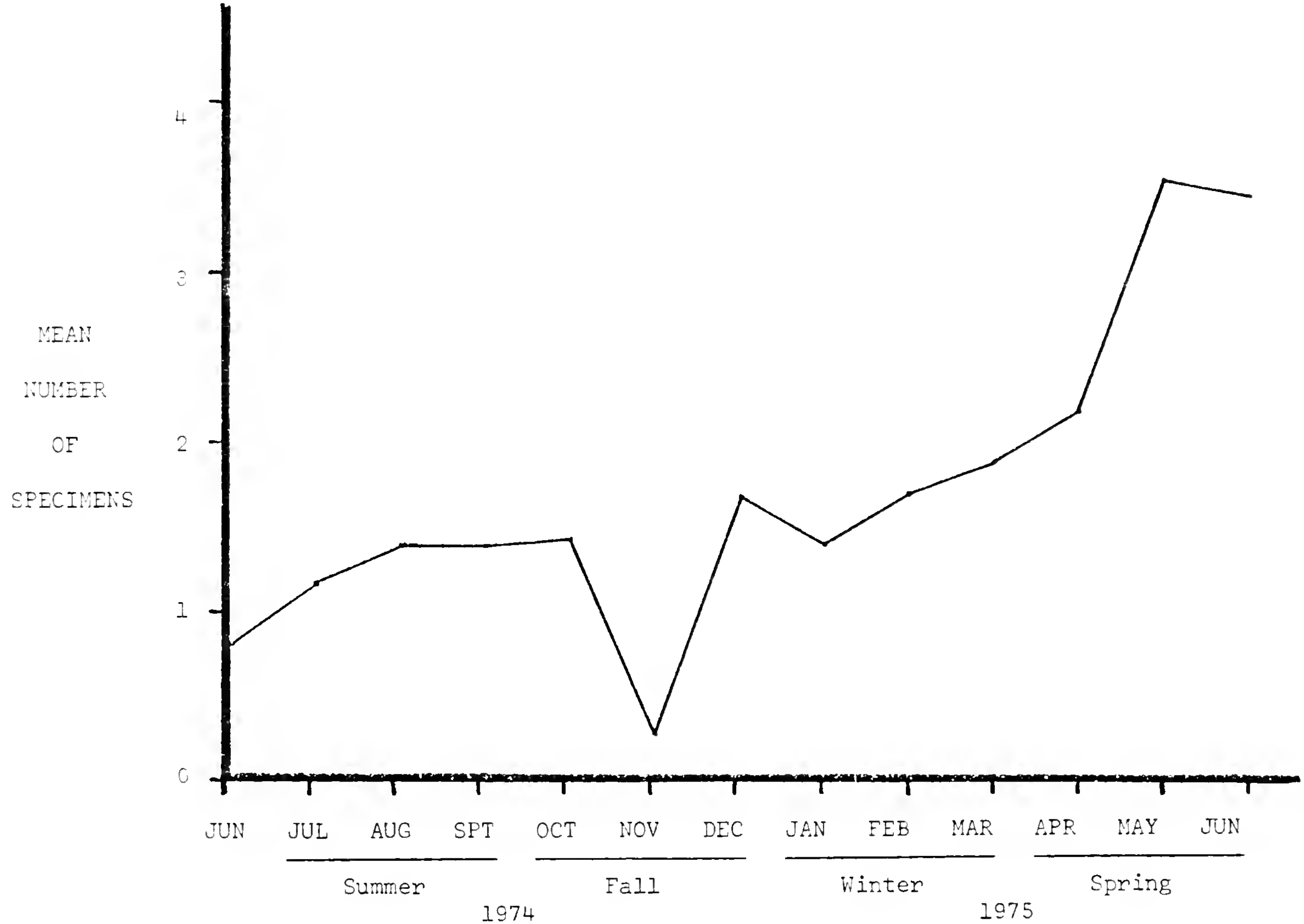


Figure 16. Monthly mean number of family Eutrachytidae from three species of turfgrass in Ft. Lauderdale, Florida. Three samples were taken every other week from each grass.

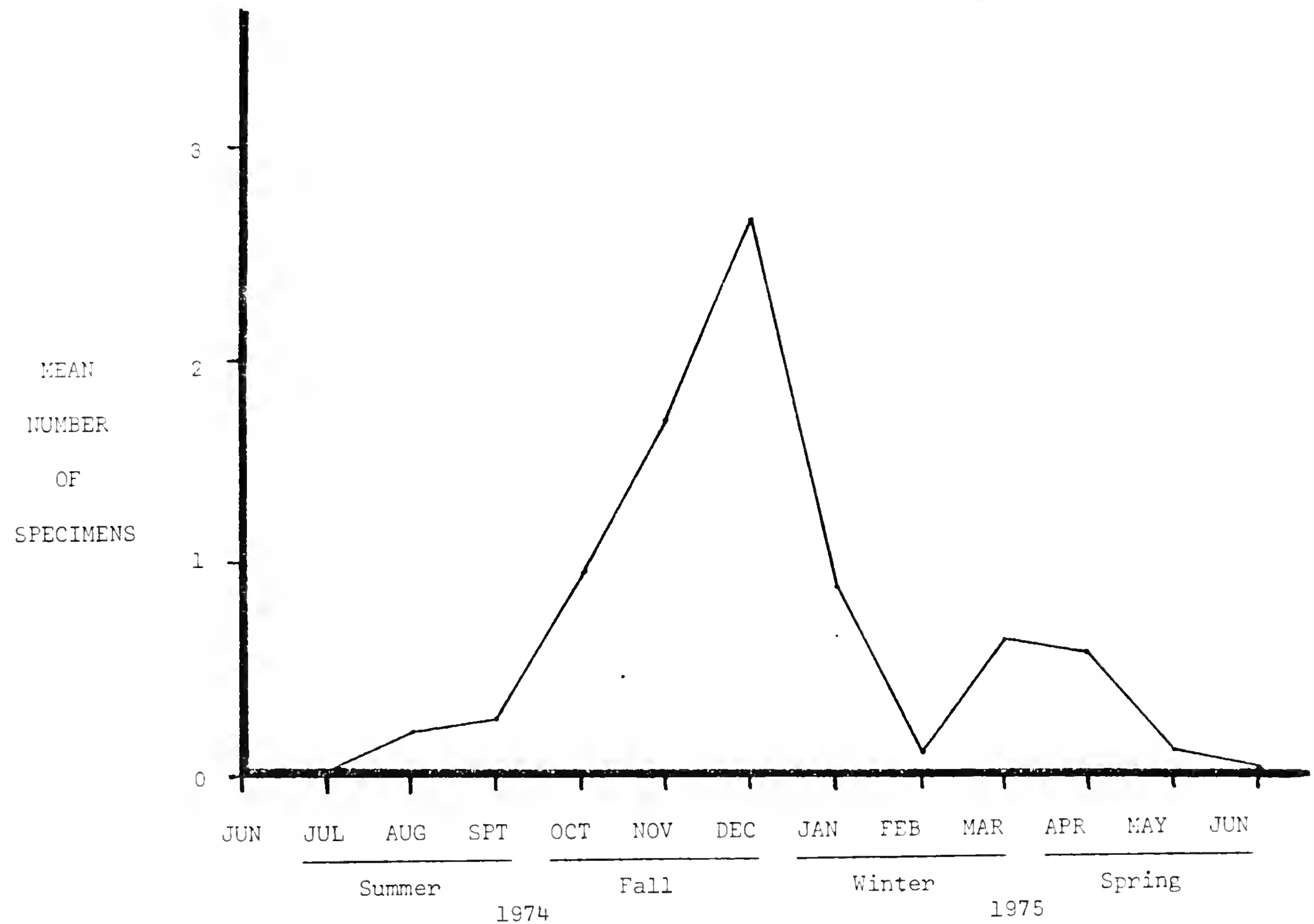


Figure 17. Monthly mean number of genus _Proprioseiopsis_ (Phytoseiidae) from three species of turfgrass in Ft. Lauderdale, Florida. Three samples were taken every other week from each grass.

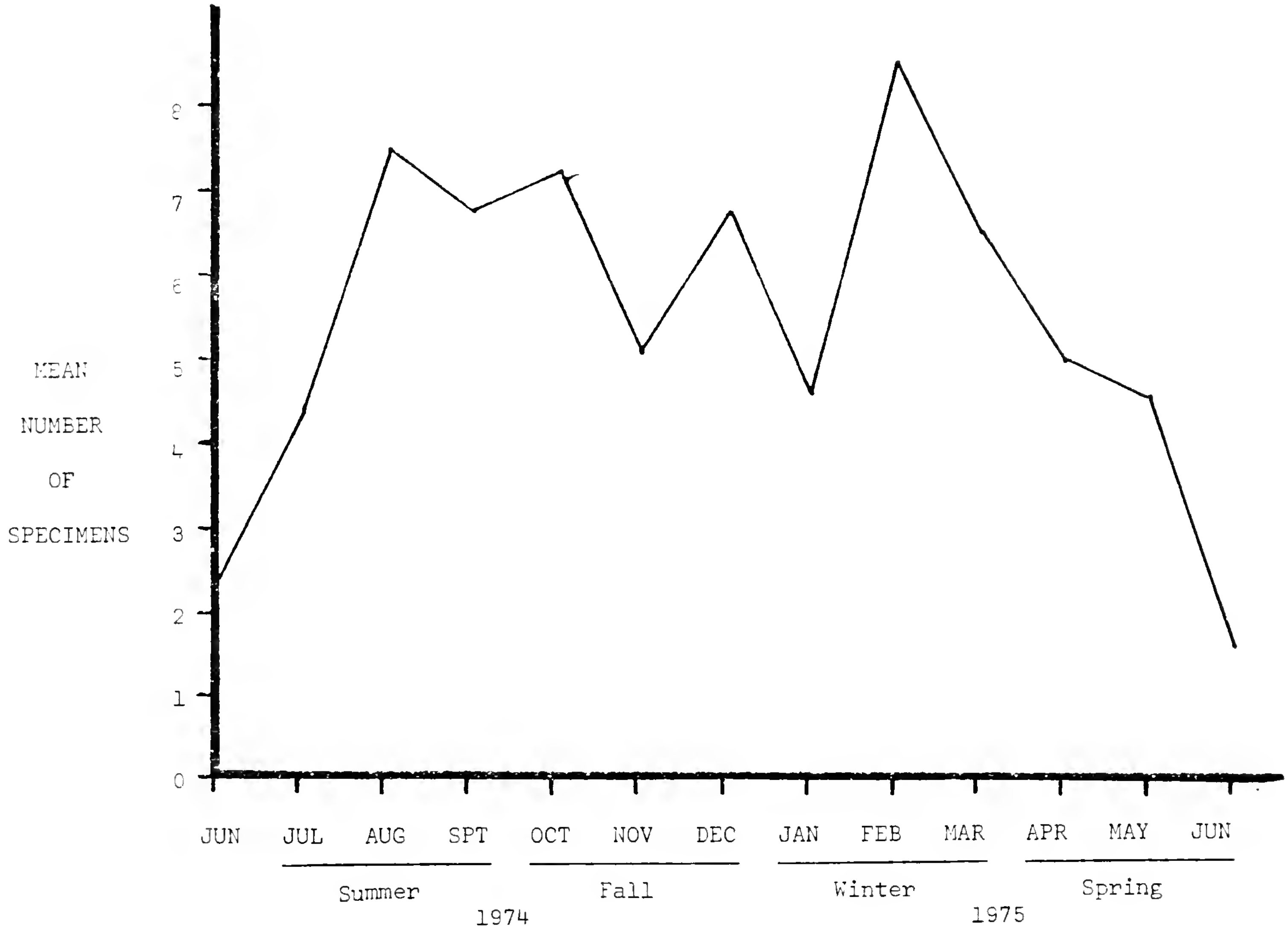


Figure 18. Monthly mean number of genus Hypoaspis (Laelapidae) from three species of turfgrass in Ft. Lauderdale, Florida. Three samples were taken every other week from each grass.

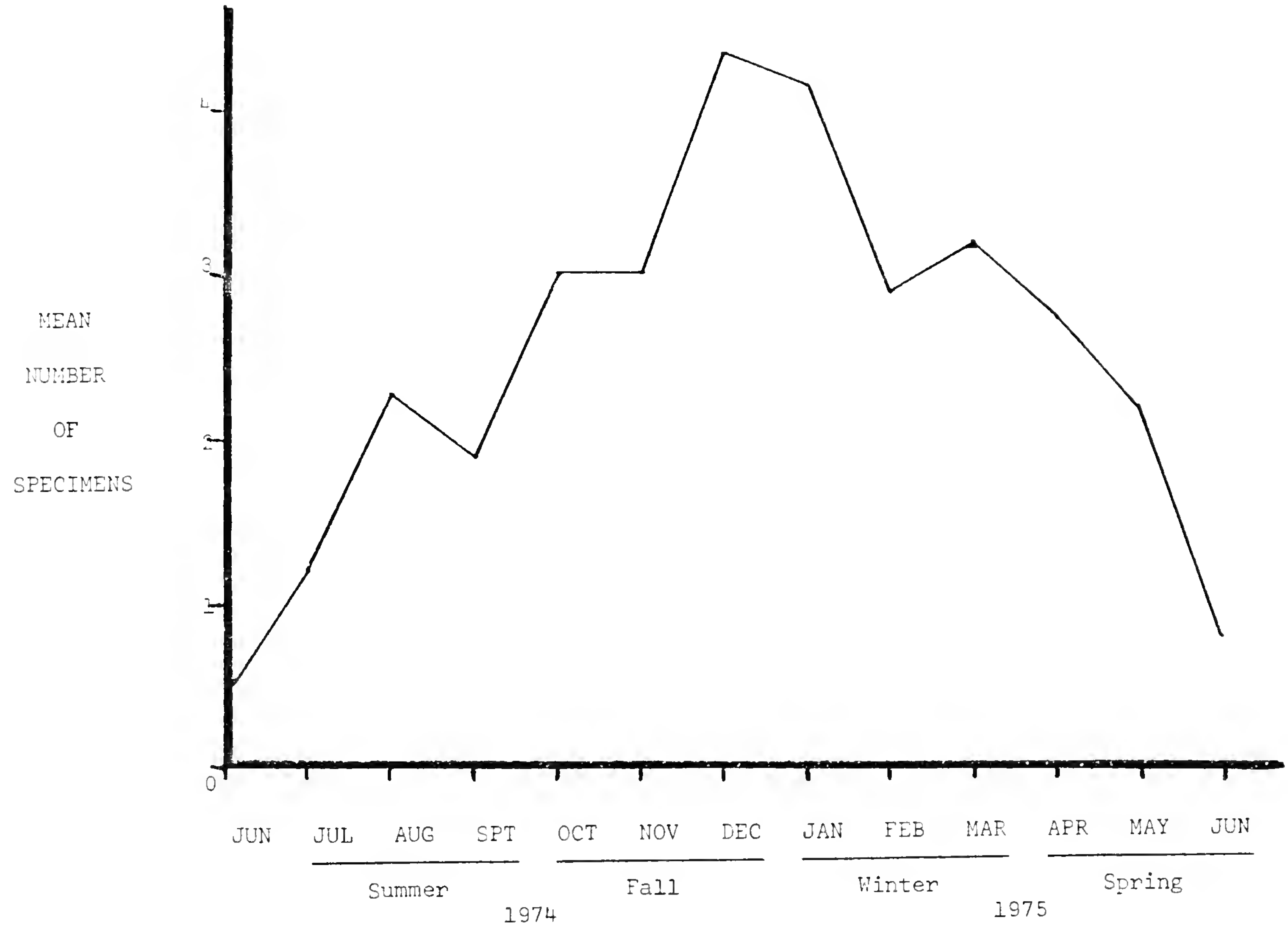


Figure 19. Monthly mean number of genus <u>Macrocheles</u> (Macrochelidae) from three species of turf-grass in Ft. Lauderdale, Florida. Three samples were taken every other week from each grass.

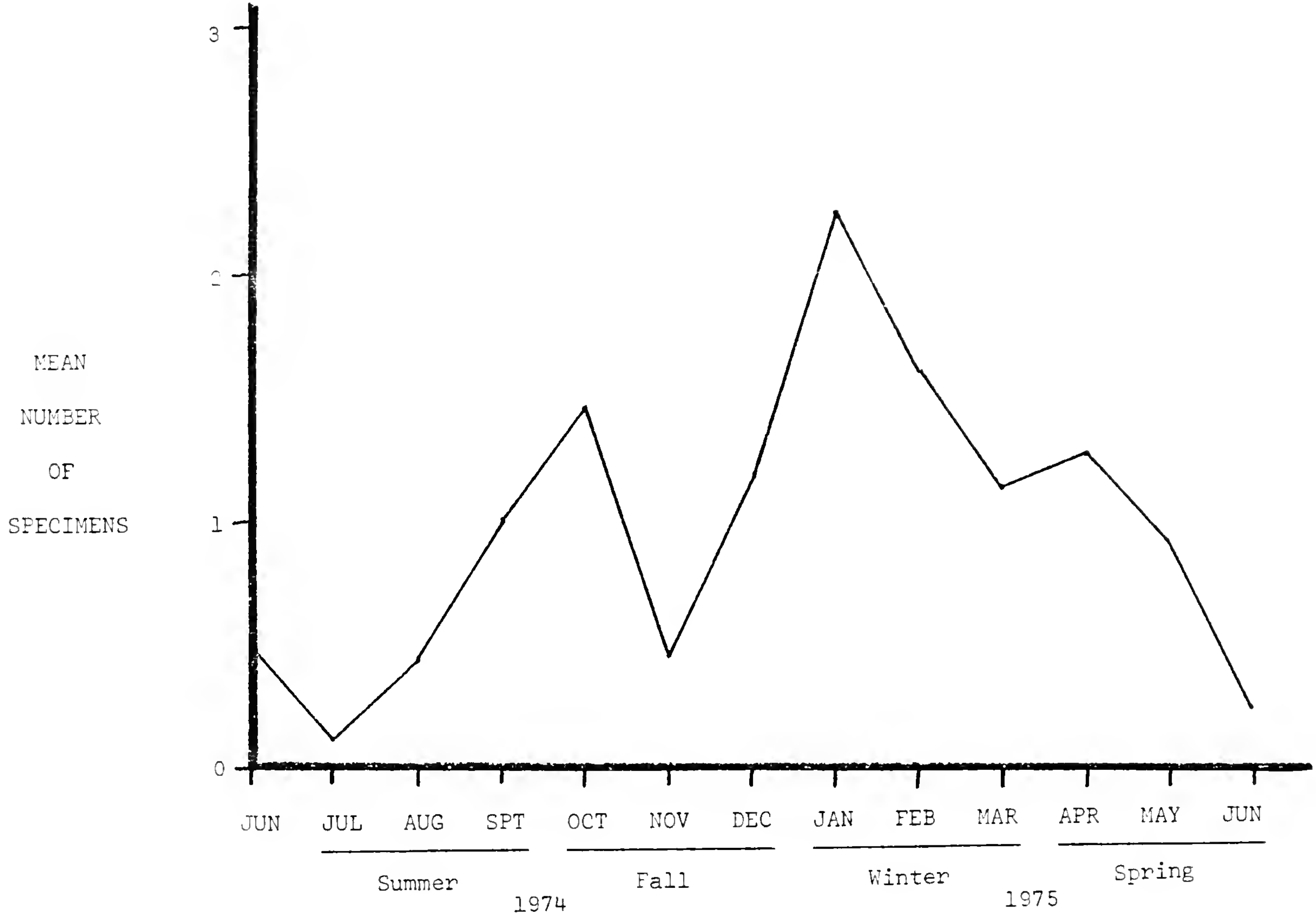


Figure 20. Monthly mean number of genus *Asca* (Ascidae) from three species of turfgrass in Ft. Lauderdale, Florida. Three samples were taken every other week from each grass.

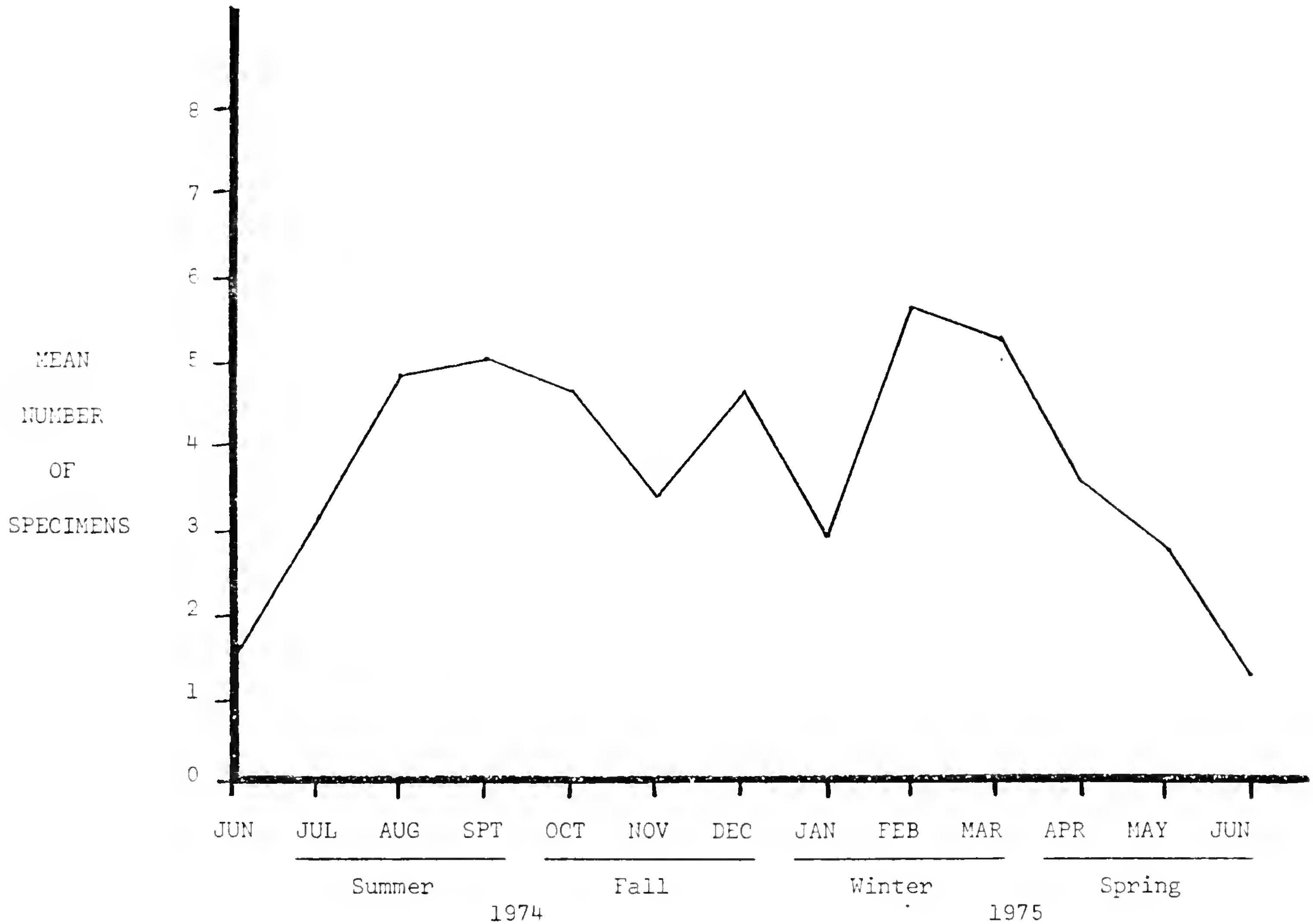


Figure 21. Monthly mean number of Hypoaspis near claviger (Berl.) from three species of turfgrass in Ft. Lauderdale, Florida. Three samples were taken every other week from each grass.

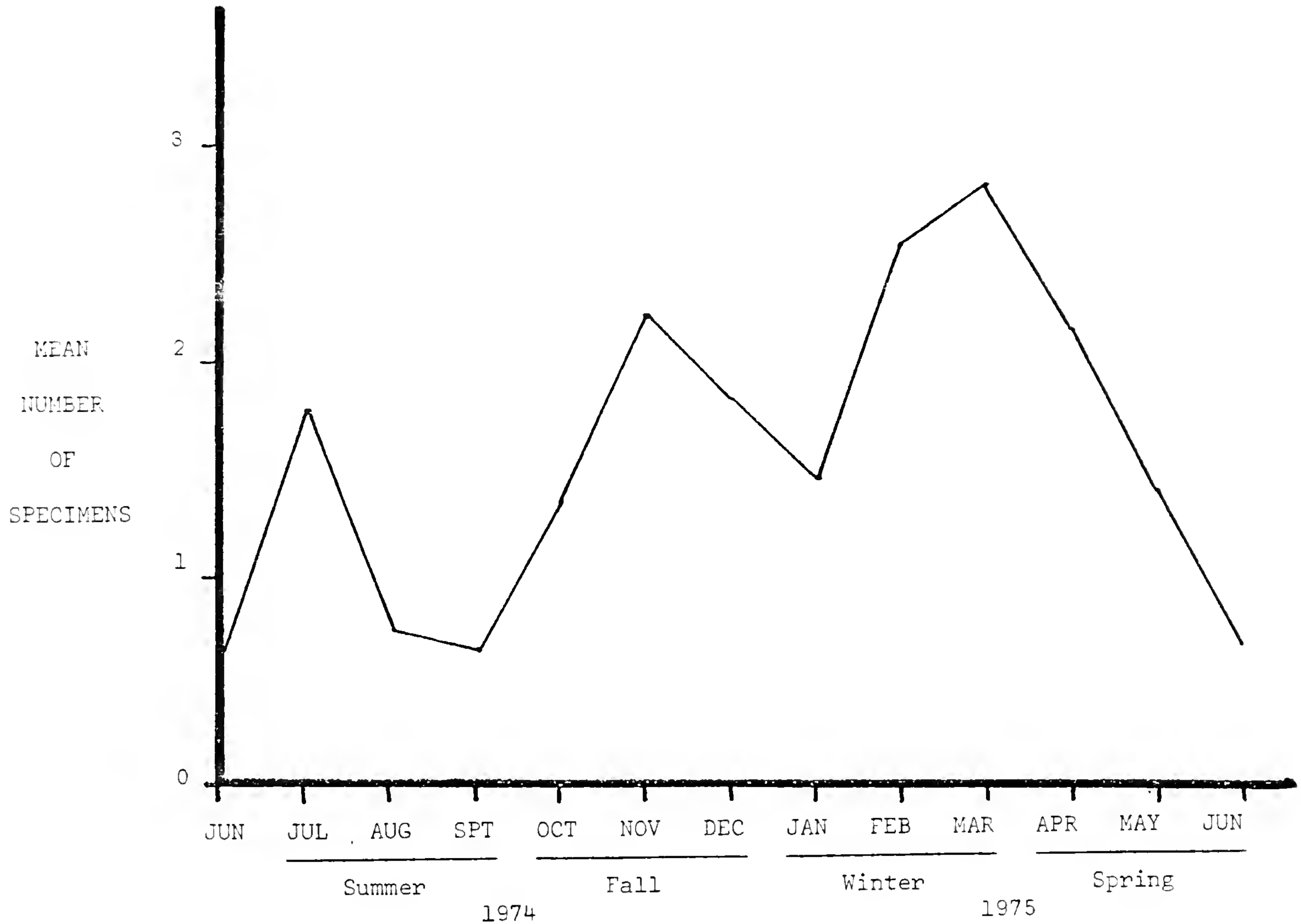


Figure 22. Monthly mean number of *Pseudoparasitus stigmatus* (Fox) from three species of turf-grass in Ft. Lauderdale, Florida. Three samples were taken every other week from each grass.

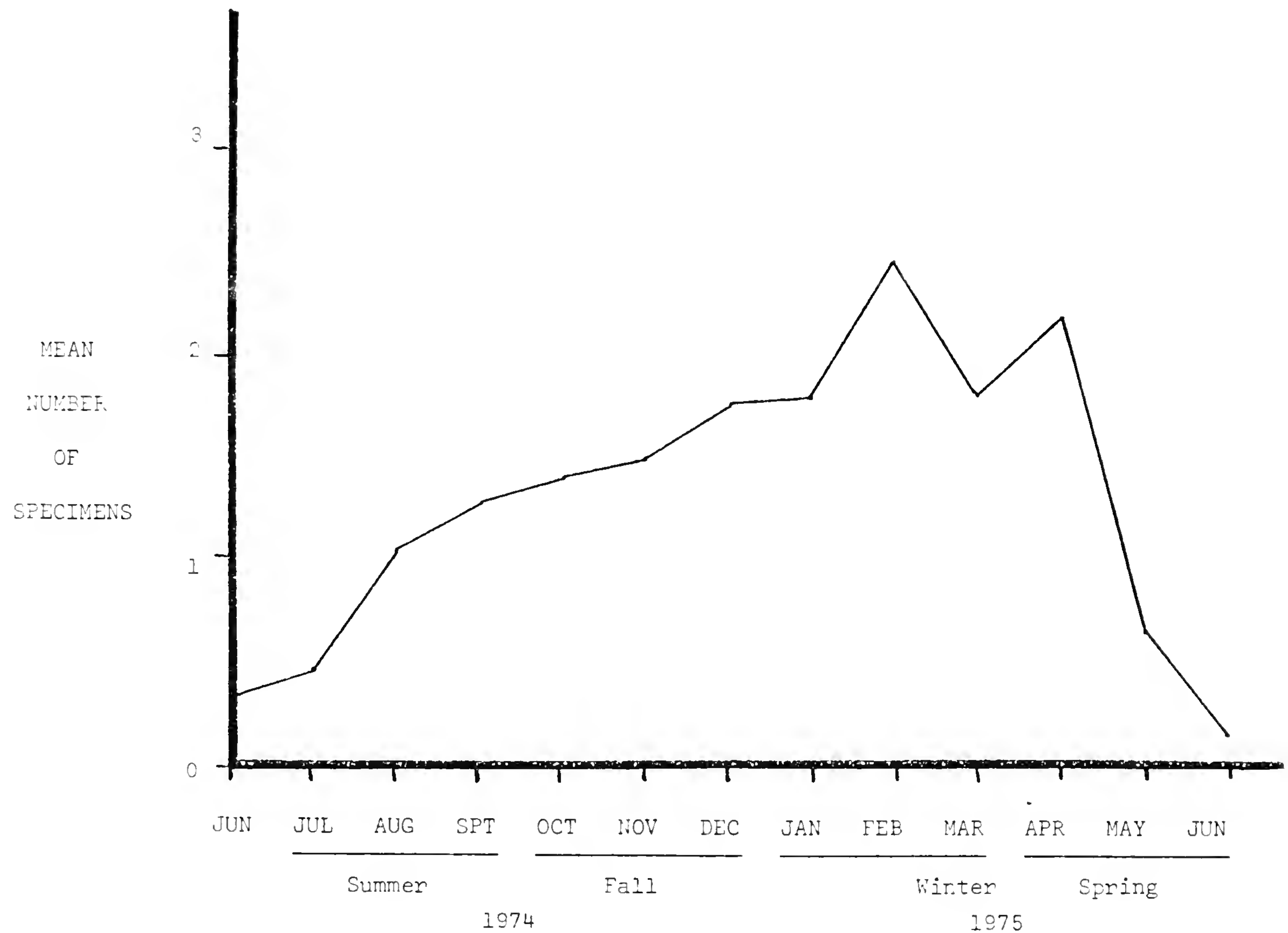


Figure 23. Monthly mean number of <u>Ololaelaps</u> sp. from three species of turfgrass in Ft. Lauderdale, Florida. Three samples were taken every other week from each grass.

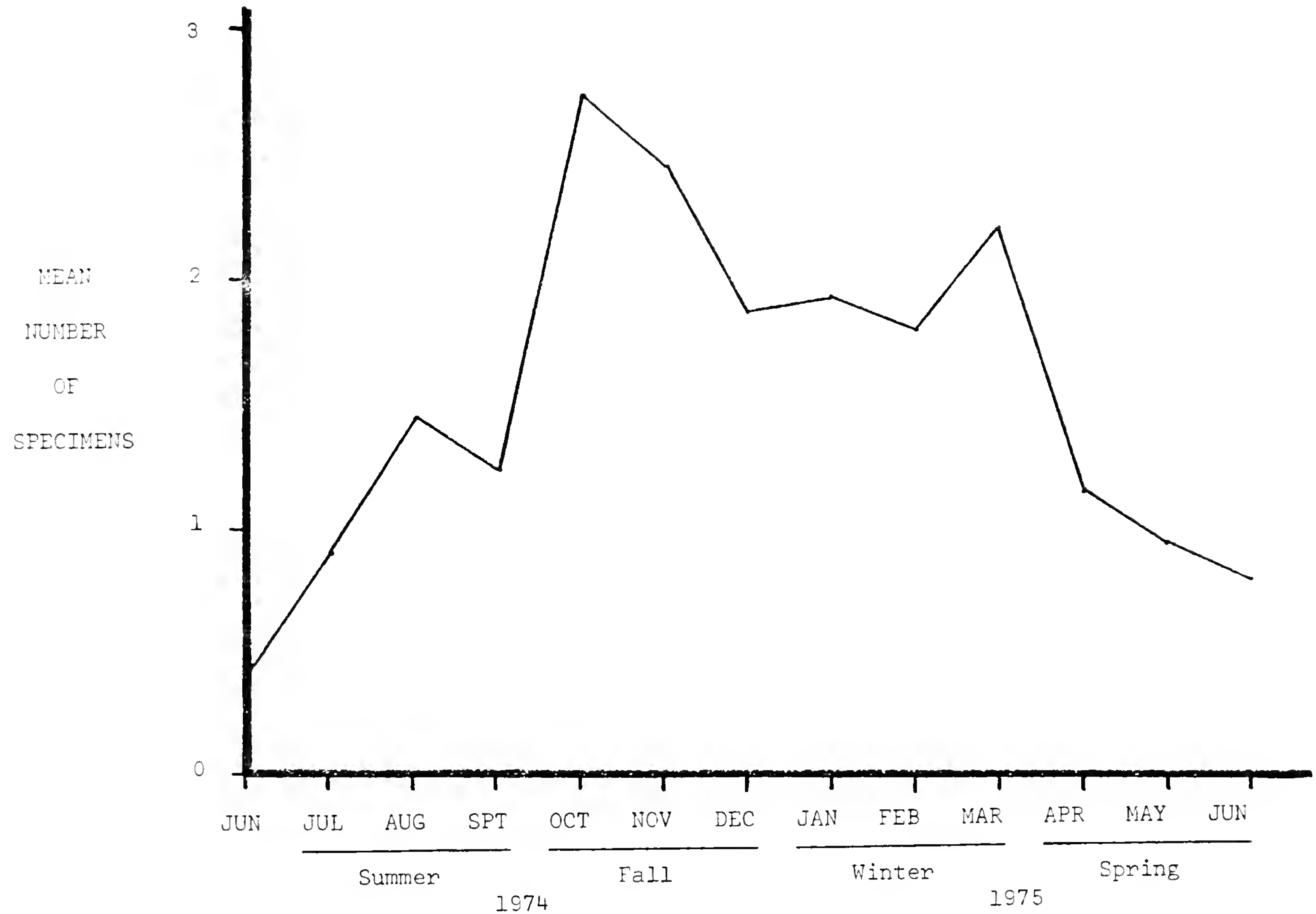


Figure 24. Monthly mean number of _Macrocheles_ near _insignitis_ from three species of turfgrass in Ft. Lauderdale, Florida. Three samples were taken every other week from each grass.

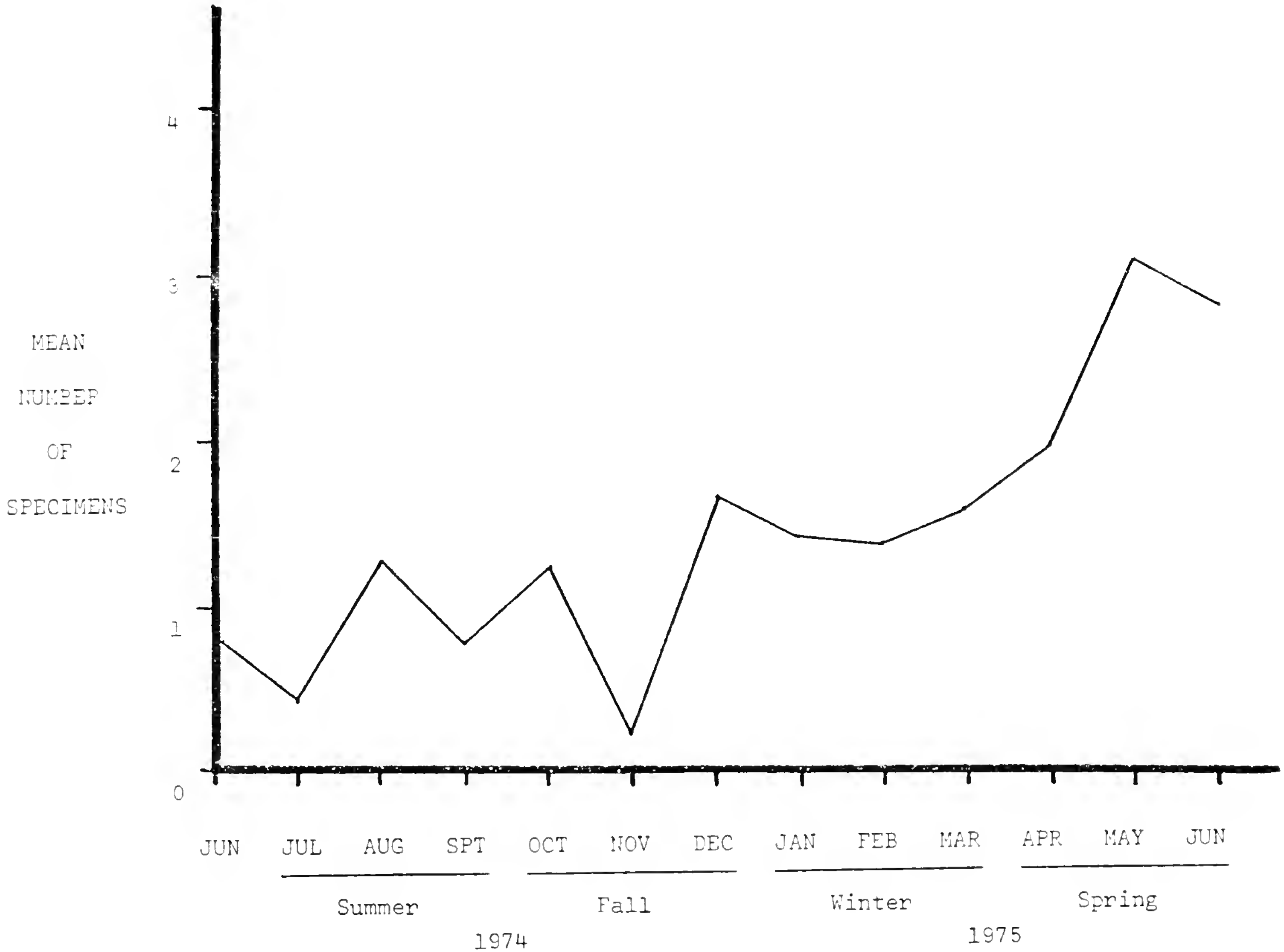


Figure 25. Monthly mean number of Leonardiella sp. from three species of turfgrass in Ft. Lauderdale, Florida. Three samples were taken every other week from each grass.

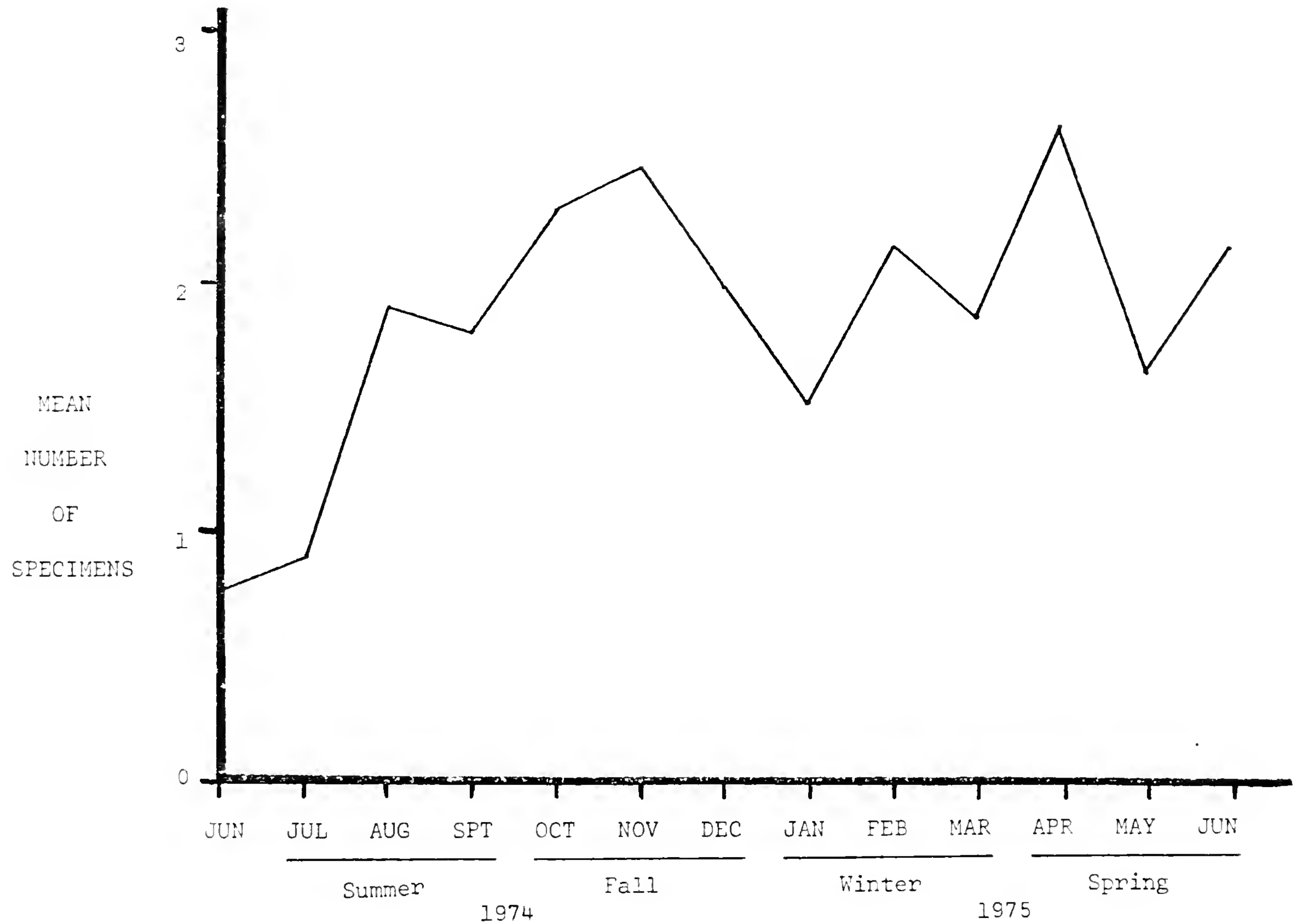


Figure 26. Monthly mean number of *Oplitis communis* from three species of turfgrass in Ft. Lauderdale, Florida. Three samples were taken every other week from each grass.

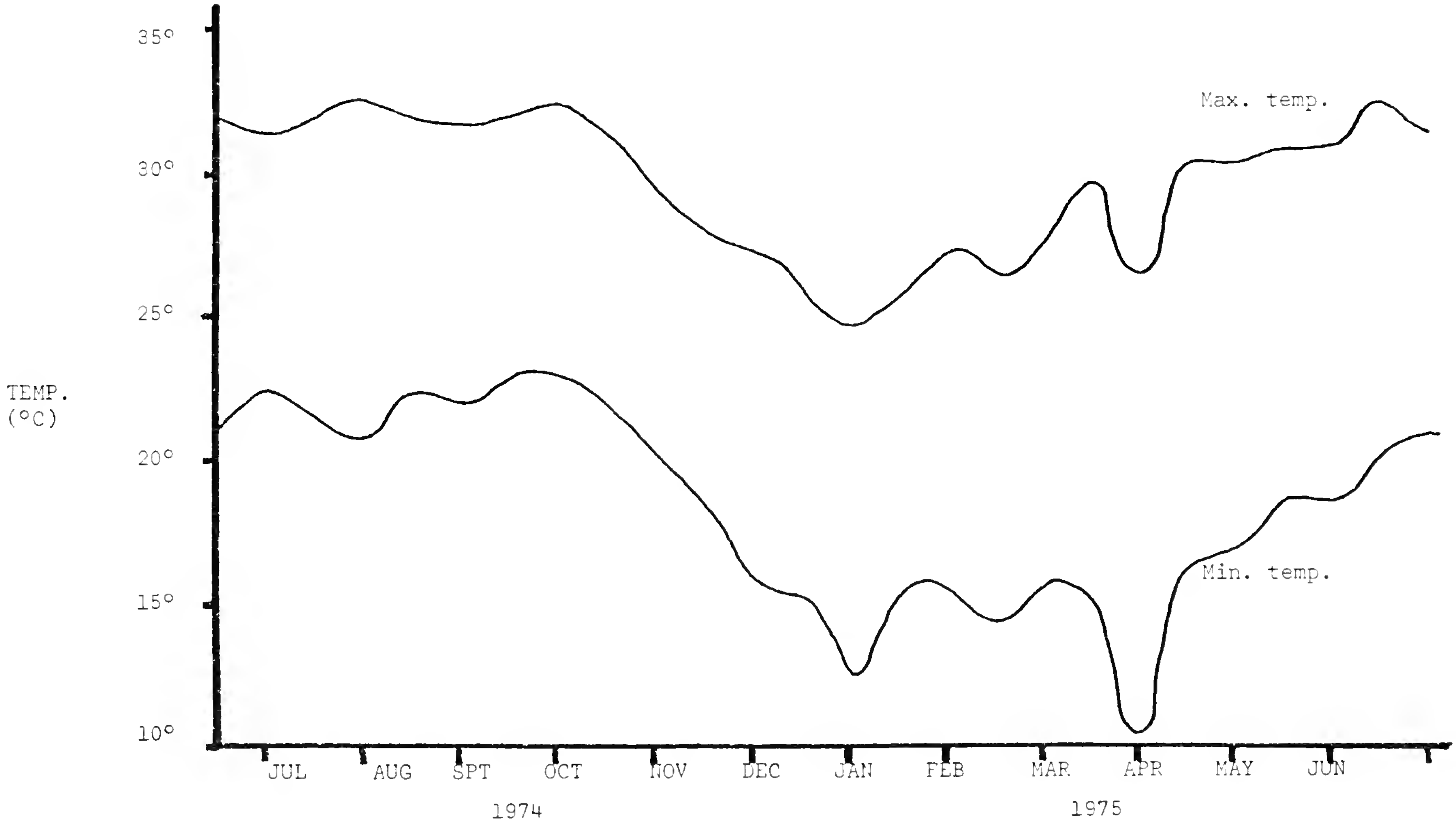


Figure 27. Maximum and minimum temperatures recorded at the University of Florida, Agricultural Research Center, Ft. Lauderdale, Florida, from June, 1974, to June, 1975. Three samples were taken every other week from each grass.

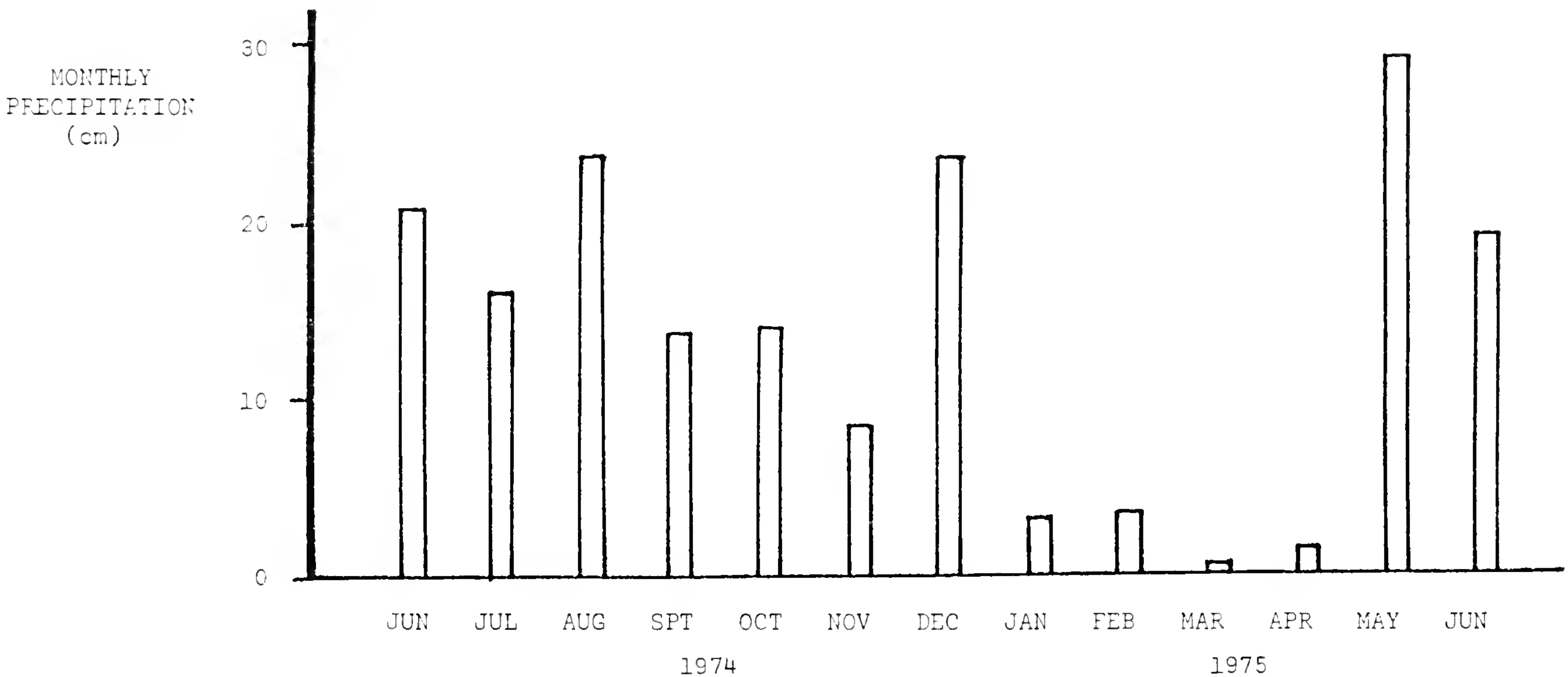


Figure 28. Monthly cumulative precipitation recorded at the University of Florida, Agricultural Research Center, Ft. Lauderdale, Florida, from June, 1974, to June, 1975. Three samples were taken every other week from each grass.

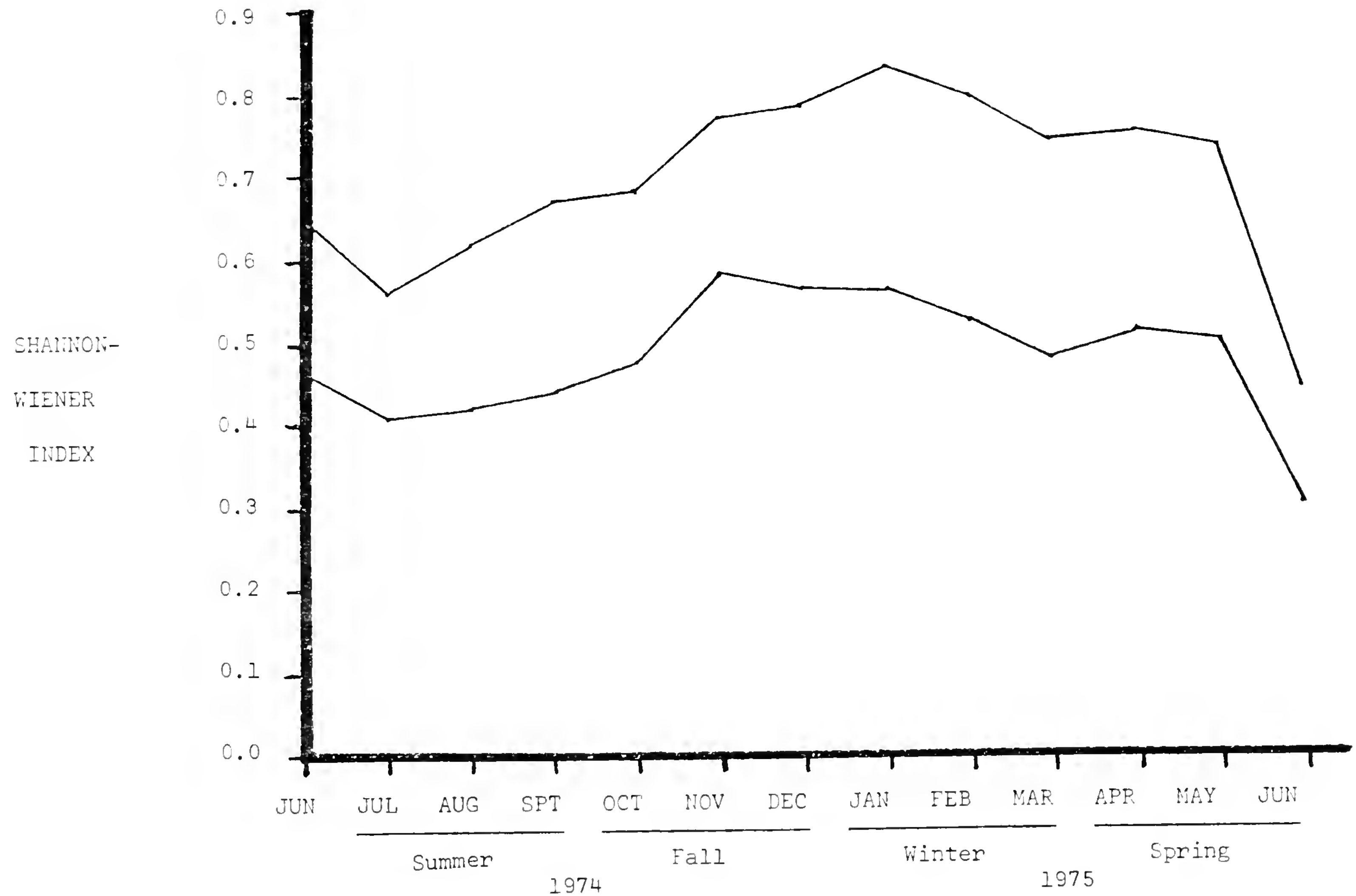
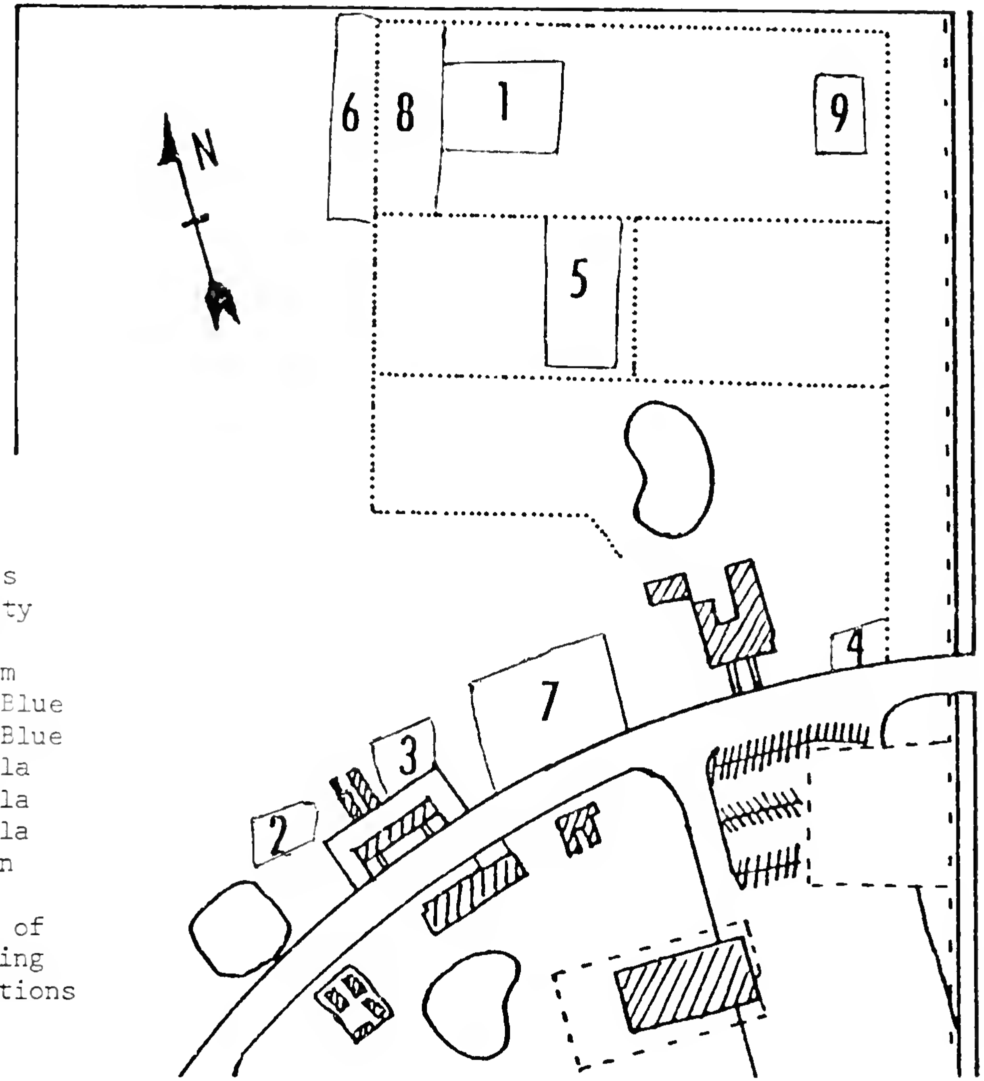


Figure 29. Monthly mean values of Shannon-Wiener index for families (H_F) and species (H_{Spp}) of Mesostigmata from slide samples collected from three species of turfgrass in Ft. Lauderdale, Florida. Three samples were taken every other week from each grass.

APPENDICES

APPENDIX I
TURF MITE SURVEY PLOTS AT THE UNIVERSITY OF FLORIDA AGRICULTURAL RESEARCH CENTER FT. LAUDERDALE, FLORIDA

Agricultural Research Center of Ft. Lauderdale
IFAS, University of Florida



LEGEND:

building
windbreak . . . .
fence ---------
pond

Scale: 0 50 100 m

Plot no.	Grass species	Grass variety
1	St. Augustine	Floritam
2	St. Augustine	Bitter Blue
3	St. Augustine	Bitter Blue
4	bahia	Pensacola
5	bahia	Pensacola
6	bahia	Pensacola
7	bermuda	Tifgreen
8	bermuda	Common
9	bermuda	Mixture of breeding selections

APPENDIX II

MONTHLY MEAN NUMBERS OF MITES AND MAJOR GROUPS OF INSECTS FROM BERLESE SAMPLES COLLECTED FROM THREE SPECIES OF TURFGRASS IN FT. LAUDERDALE, FLORIDA

Month		Mean Number of Specimens*				
		Mites	Collembola	Ants	Scales	Thrips
	JUN	3876	509	25	124	14
Summer	JUL	3271	526	51	125	18
	AUG	2963	446	83	42	7
	SPT	2796	311	69	25	10
Fall	OCT	3147	468	115	145	15
	NOV	4931	1202	162	122	23
	DEC	4432	1038	58	207	19
Winter	JAN	2833	928	111	61	20
	FEB	3986	988	72	94	15
	MAR	4541	744	120	72	17
Spring	APR	4930	664	120	113	17
	MAY	2926	541	239	294	12
	JUN	2356	578	142	282	23

*The numbers have been rounded off to eliminate decimal points.

APPENDIX III

MEAN NUMBERS OF MAJOR ARTHROPOD GROUPS FROM BERLESE SAMPLES AND MITE SUBORDERS FROM SLIDE SAMPLES COLLECTED FROM THREE SPECIES OF SOUTH FLORIDA TURFGRASS, COMPARED BY GRASS SPECIES AND SEASONS

			Summer			Fall			Winter			Spring	
	JUNJUL	AUG	SPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	
St. Augustine													
Berlese Samples													
Mites	3203.0	2827.6	2729.5	2179.3	3834.3	4369.0	2856.0	2307.8	3172.3	2555.6	3561.8	2681.8	2744.0
Collembola	1172.0	728.0	643.1	409.1	994.1	1989.1	843.7	647.5	903.8	821.6	697.8	609.6	1009.6
Ants	12.6	75.5	113.8	76.1	192.8	92.5	38.1	53.3	38.5	29.1	54.6	196.6	164.3
Scales	94.3	13.6	28.0	2.6	45.1	46.8	1.2	8.1	77.0	1.8	68.0	311.5	677.0
Thrips	15.6	35.6	13.1	10.5	27.3	36.6	29.1	22.3	4.3	10.1	11.5	16.8	15.6
Slide Samples													
Mesostigmata	14.6	20.3	23.3	17.0	33.5	28.6	30.2	13.6	49.4	30.0	32.0	28.8	12.6
Cryptostigmata	13.0	23.0	42.1	36.3	32.5	51.3	33.5	39.5	31.8	23.5	29.2	35.8	32.0
Prostigmata	10.0	6.0	25.0	18.3	33.0	17.0	18.6	22.8	8.6	28.3	31.2	37.3	50.6
Astigmata	0.0	0.0	1.3	0.3	0.5	2.0	0.5	0.3	0.2	0.5	1.4	0.3	0.3
Bahiagrass													
Berlese Samples													
Mites	3636.0	4215.5	4056.0	4060.6	4047.5	5677.8	5789.8	5942.0	6332.0	8729.3	7057.5	3438.8	2737.0
Collembola	268.3	245.8	239.5	192.5	247.5	525.0	669.2	631.8	540.1	241.6	381.8	388.8	271.0
Ants	15.3	33.5	100.5	26.8	83.0	323.8	78.4	163.6	87.1	175.6	77.1	397.8	204.0
Scales	16.3	42.3	42.3	36.0	318.5	108.5	385.3	35.8	170.1	81.0	20.5	317.0	23.6
Thrips	21.0	18.0	7.0	18.0	16.3	24.8	23.7	33.1	37.5	39.3	32.3	19.1	55.0
Slide Samples													
Mesostigmata	9.0	9.6	20.3	21.6	24.0	29.0	26.4	28.6	29.6	29.5	23.6	18.5	16.3
Cryptostigmata	14.3	20.6	25.1	52.3	40.6	51.0	43.7	49.0	33.3	38.5	34.0	42.0	40.0
Prostigmata	15.3	3.6	19.0	19.3	32.3	24.0	27.0	24.8	15.6	29.5	40.8	31.3	41.6
Astigmata	0.0	1.0	0.1	0.3	0.8	0.0	2.5	1.1	0.3	0.8	0.1	0.5	0.3

Bermudagrass													
Berlese Samples													
Mites	4799.0	2771.5	2103.0	2148.5	1558.8	4748.1	4652.0	3217.1	2452.8	2340.1	4021.4	2659.6	1589.0
Collembola	88.0	606.1	457.6	331.1	163.3	1093.8	1603.4	1506.3	1520.5	1169.6	962.4	625.6	454.6
Ants	47.6	45.3	36.3	103.3	70.8	71.0	59.0	116.5	91.5	155.8	249.2	124.5	59.0
Scales	262.6	320.8	56.5	37.1	71.8	209.6	236.7	138.0	35.6	133.6	278.4	255.6	147.3
Thrips	5.0	0.5	1.6	0.3	2.8	7.8	5.0	4.6	3.3	1.8	5.6	0.8	0.3
Slide Samples													
Mesostigmata	4.6	8.3	20.6	18.0	19.0	18.0	33.7	35.3	19.3	19.5	19.2	17.6	3.3
Cryptostigmata	12.6	14.3	28.0	57.6	46.3	56.0	43.8	49.1	49.0	29.8	49.6	49.0	36.6
Prostigmata	3.6	5.3	10.5	8.3	30.0	22.6	17.1	27.1	25.8	25.0	33.4	29.6	42.3
Astigmata	1.3	0.6	1.6	6.0	2.3	17.0	1.1	0.5	0.6	0.1	0.0	0.8	0.0

APPENDIX IV
MONTHLY MEAN NUMBERS OF FOUR MITE SUBORDERS FROM SLIDE SAMPLES COLLECTED FROM THREE SPECIES OF TURFGRASS IN FT. LAUDERDALE, FLORIDA

Month		Mean Number of Mites				
		Cryptostigmata	Prostigmata	Astigmata	Mesostigmata	TOTAL
	JUN	13.11	9.67	0.44	9.50	32.60
Summer	JUL	19.33	5.00	0.56	12.78	37.67
	AUG	31.78	18.17	1.06	21.44	72.45
	SPT	48.78	15.33	2.22	18.99	85.22
Fall	OCT	39.83	31.78	1.22	25.50	98.33
	NOV	52.78	21.22	6.33	25.22	105.22
	DEC	40.41	20.92	1.41	30.15	92.89
Winter	JAN	45.89	24.94	0.67	25.89	97.39
	FEB	38.41	17.18	0.41	31.82	87.82
	MAR	30.61	27.61	0.50	26.33	85.05
Spring	APR	37.18	36.06	0.47	24.65	98.36
	MAY	42.28	32.78	0.56	21.67	97.29
	JUN	36.22	44.89	0.22	10.78	92.11

APPENDIX V

MONTHLY MEAN NUMBERS OF MAJOR FAMILIES OF MESOSTIGMATA FROM SLIDE SAMPLES COLLECTED FROM THREE SPECIES OF TURFGRASS IN FT. LAUDERDALE, FLORIDA

Month		Mean Number of Mites						
		Macrochelidae	Laelapidae	Phytoseiidae	Ascidae	Rhodacaridae	Uropodidae	Eutrachytidae
	JUN	0.55	3.55	0.11	1.44	1.33	0.89	0.78
Summer	JUL	1.33	6.55	0.11	0.78	0.66	1.22	1.11
	AUG	2.28	10.05	0.28	1.94	2.05	2.39	1.33
	SPT	1.89	9.22	0.33	2.33	0.55	2.66	1.33
Fall	OCT	3.00	11.00	1.28	3.94	1.22	3.05	1.39
	NOV	3.00	8.78	1.89	5.44	1.66	2.89	0.22
	DEC	4.51	10.29	2.78	4.44	1.81	2.52	1.63
Winter	JAN	4.61	8.11	0.94	6.22	0.89	2.55	1.39
	FEB	3.53	13.53	0.23	5.53	1.65	2.76	1.65
	MAR	3.39	12.11	0.72	4.22	0.67	2.22	1.83
Spring	APR	3.12	9.62	0.94	4.25	1.37	2.75	2.12
	MAY	2.33	7.05	0.33	3.16	1.61	2.05	3.50
	JUN	0.89	2.78	0.22	1.22	0	2.11	3.44

APPENDIX VI

MONTHLY MEAN NUMBERS OF MAJOR GENERA AND SPECIES OF MESOSTIGMATA FROM SLIDE SAMPLES COLLECTED FROM THREE SPECIES OF TURFGRASS IN FT. LAUDERDALE, FLORIDA

		Mean Number of Mites									
	Month	*Proprioseiopsis* spp.	*Hypoaspis* spp.	*Macrocheles* spp.	*Asca* spp.	*Hypoaspis* near *claviger*	*Pseudoparasitis stigmatus*	*Ololaelaps* sp.	*Macrocheles* near *insignitis*	*Leonardiella* sp.	*Oplitis communis*
	JUN	0	2.33	0.55	0.44	1.66	0.66	0.33	0.44	0.78	0.78
Summer	JUL	0	4.33	1.22	0.11	3.22	1.78	0.44	0.89	0.44	0.89
	AUG	0.17	7.44	2.28	0.44	4.83	0.78	1.00	1.44	1.28	1.89
	SPT	0.22	6.67	1.89	1.00	5.00	0.57	1.22	1.22	0.78	1.78
Fall	OCT	0.94	7.17	3.00	1.44	4.61	1.33	1.39	2.72	1.22	2.28
	NOV	1.67	5.00	3.00	0.44	3.44	2.22	1.44	2.44	0.22	2.44
	DEC	2.63	6.63	4.33	1.18	4.59	1.81	1.70	1.85	1.63	1.96
Winter	JAN	0.89	4.55	4.11	2.22	2.89	1.44	1.72	1.89	1.39	1.50
	FEB	0.06	8.47	2.88	1.59	5.59	2.53	2.41	1.78	1.35	2.12
	MAR	0.61	6.44	3.17	1.11	5.22	2.83	1.78	2.17	1.56	1.83
Spring	APR	0.56	4.94	2.70	1.23	3.50	2.12	2.12	1.11	1.94	2.59
	MAY	0.05	4.50	2.17	0.89	2.78	1.39	0.61	0.89	3.06	1.61
	JUN	0	1.55	0.78	0.22	1.22	0.67	0.11	0.78	2.78	2.11

APPENDIX VII
MONTHLY MEAN VALUES OF SHANNON-WIENER INDEX
FOR FAMILIES (H_F) AND SPECIES (H_{spp}) OF MESOSTIGMATA
FROM SLIDE SAMPLES COLLECTED FROM THREE SPECIES OF TURFGRASS
IN FT. LAUDERDALE, FLORIDA

	Month	H_F	H_{spp}
	JUN	0.46	0.64
Summer	JUL	0.41	0.56
	AUG	0.42	0.62
	SPT	0.44	0.67
Fall	OCT	0.48	0.68
	NOV	0.58	0.77
	DEC	0.56	0.78
Winter	JAN	0.56	0.83
	FEB	0.52	0.79
	MAR	0.48	0.74
Spring	APR	0.51	0.75
	MAY	0.50	0.73
	JUN	0.30	0.44

APPENDIX VIII
MONTHLY MEAN NUMBERS OF FOUR MITE SUBORDERS
FROM DROP SAMPLES COLLECTED FROM THREE SPECIES OF TURFGRASS
IN FT. LAUDERDALE, FLORIDA

Month		Mean Number of Mites					
		Cryptostigmata	Prostigmata	Astigmata	Mesostigmata	TOTAL	N
	JUN	10.78	14.94	0.15	5.84	31.71	19
Summer	JUL	12.50	1.60	0.30	1.45	15.85	18
	AUG	15.23	4.53	0.08	2.32	22.16	56
	SPT	18.83	8.22	0.13	3.86	31.04	36
Fall	OCT	23.02	9.91	0.13	2.36	35.42	36
	NOV	22.96	16.87	0.18	5.75	45.76	32
	DEC	23.71	11.58	0.40	4.59	40.28	91
Winter	JAN	21.00	9.26	0.07	3.61	33.94	63
	FEB	22.92	13.32	0.02	4.54	40.80	68
	MAR	27.48	16.91	0.01	4.27	48.67	72
Spring	APR	20.80	22.76	0.00	6.28	49.84	56
	MAY	17.00	10.90	0.09	3.70	31.69	44
	JUN	28.32	14.92	0.10	5.45	48.79	4

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BIOGRAPHICAL SKETCH

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Thomas C. Emmel
Professor of Zoology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

James A. Reinert
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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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This dissertation was submitted to the Graduate Faculty of the College of Agriculture and to the Graduate Council, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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