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16. Abstract
We sampled arthropods biweekly from ashe juniper, Texas oak, live oak, and cedar elm throughout the activity period of the golden-cheeked warbler (GCWA) in central Texas (March 1 - July 31). A datatbase of arthropod species collected by date, site, height, and tree species was compiled. To provide a better context for discussion of these data, we also re-examined the stomach contents analyzed by Pulich (1976) for his study on GCWA diet. We collected and identified over 50,000 arthropods from tree species in which GCWAs normally forage. These totals include approximately 35,000 insects and 15,000 arachnids (mostly spiders). At least 1600 species were represented in the samples, ranging in size from less than 1 mm (certain mites and parasitic wasps) to more than 5 cm (2 inches) (several walking sticks). Based on analysis of the stomach contents of 22 GCWA, as well as observations on feeding behavior made by Pulich and others, all of these arthropods are potential prey for warblers.

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IMPLEMENTATION STATEMENT

The study findings clearly indicate that large numbers of suitable invertebrate prey are available to the golden-cheeked warbler throughout the breeding season, on all four tree species sampled, and at all three sample heights. Further sampling of available prey would therefore not be fruitful in the context of warbler biology, given the catholic diet of the warbler.

However, specific prey items taken by warblers and recorded on film or by direct observation can now be more readily identified by reference to the voucher collection prepared from this study. Voucher specimens are housed in the Insect Collection at Texas A&M University.

DISCLAIMER

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Mike Quinn conduted much of the work in partial fulfillment for his M. S. degree at Texas A&M University. He took on the responsibility, under Robert Wharton's direction, for organizing all the field work and all the sample sorting. He also processed most of the data. This study would not have been possible without the assistance of an enthusiastic group of students who helped collect and process the samples. These included Kelly Alexander, Tommy Armstong, Allison Arnold, Carrie Cate, Chris Clemens, Stephanie Compton, Rachel Donovan, Julie Dunlap, Randy Gibson, Al Gillogly, Sharon Jasper, Shirley Lanza, Mike Matthiesen, Amy Mercer, David Seale, Erika Stieber, Carla Weinkauf, Kari Wikse, and Kimberly Willis. We are particularly grateful to Cal Newnam for assistance with site selection and general support throughout the project.

Research performed in cooperation with the Texas Department of Transportation.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Page

SUMMARY

Our goal was to provide a qualitative assessment of the arthropod prey species available to the golden-cheeked warbler (GCWA) in its breeding habitat. To accomplish this, the research team sampled arthropods biweekly from four tree species throughout the activity period of GCWA in central Texas (March 1 - July 31). Samples were taken from ashe juniper, Texas oak, live oak, and cedar elm in areas of western Travis County where GCWA has nested on a regular basis. In addition to the four tree species, three height categories were assessed: 0-3m, 3-5m, and >5m. We sampled in Long Hollow during the 1993 breeding season and added a second site (Shellberg) during the 1994 season.

A database of arthropod species collected by date, site, height, and tree species was compiled. To provide a better context for discussion of these data, we also re-examined the stomach contents analyzed by Pulich (1976) for his study on GCWA diet, the most detailed information available on the food and feeding of GCWA. Reanalysis of the Pulich samples supports the evidence presented by Pulich that GCWA is a generalist arthropod predator. Individual stomachs contained a wide diversity of prey items, with little evidence of specialization. Based on this reanalysis, we are confident that the samples we collected from trees in Travis County are representative of the bird's diet.

During the study, we collected and identified over 50,000 arthropods from tree species in which GCWAs normally forage. These totals include approximately 35,000 insects and 15,000 arachnids (mostly spiders). At least 1600 species were represented in the samples, ranging in size from less than 1 mm (certain mites and parasitic wasps) to more than 5 cm (2 inches) (several walking sticks). Based on our analysis of the stomach contents of 22 GCWA, as well as observations on feeding behavior made by Pulich and others (Pulich, 1976), all of these arthropods are potential prey for warblers.

There were significant differences in the arthropod composition between the Shellberg and Long Hollow sites in 1994 and between 1993 and 1994 at the Long Hollow site. Approximately 2000 more insects were collected at the Long Hollow site in 1993 than in 1994, despite the fact that more samples were taken in 1994. Flies and caterpillars were notably more abundant in 1993 than 1994 and bark lice (Psocoptera) were significantly more abundant in 1994 than 1993.

Although arthropods were collected in large numbers from all four tree species, many of the arthropod species showed decided preferences for a particular tree species. Height differences were less pronounced, though more arthropods were collected at the 0-3 m height than at either 3-5 m or >5 m. Thus, the collections demonstrate clearly that large numbers of suitable prey are available at all three of the height categories that were sampled, and that arthropods in general occur in roughly comparable numbers on all four tree species.

INTRODUCTION

The golden-cheeked warbler (*Dendroica chrysoparia*) (GCWA) was placed on the federal list of endangered species in 1990. It breeds in central Texas, generally in association with juniper woodlands, but little is known about its food preferences. The impact of habitat loss on the food base used by the warbler thus cannot be adequately assessed. This study provides baseline data on food availability in known nesting sites during the warbler's breeding season. Based on previous observations on foraging behavior in the Austin area, we selected four tree species (*Quercus virginiana*, *Q. buckleyi*, *Juniperus ashei*, and *Ulmus crassifolia*) in which the warbler regularly foraged, and sampled the arthropod fauna from these trees.

STUDY SITES

Federal wildlife officials selected study sites on researchers' behalf in consultation with a Texas Department of Transportation (TxDOT) representative. Our principal study site was located in northwestern Travis County on Lower Colorado River Authority (LCRA) land and adjacent Nature Conservancy lands bordering Long Hollow Creek. Approximately 20 golden-cheeked warbler territories were mapped on this site in 1992 by TxDOT personnel. Surveys of the invertebrate fauna during the first year (1993) were conducted exclusively at this site. During the 1994 season, we compared this site with a second site (Shellberg) a little to the southeast, adjacent to Lake Travis . As with the Long Hollow site, numerous warbler territories were observed at the Shellberg site in 1992.

SAMPLING METHODS

Trees or groups of trees of sufficient height, accessibility, and quantity of foliage for sampling invertebrates were individually numbered at each study site, and four such "trees" of each species were randomly selected for sampling during each site visit. Trees were sampled every two weeks during the GCWA breeding season (March 1 through July 31). Four tree species were chosen for intensive sampling, with samples divided uniformly into three height classes: [0-3m, 3-5m , and above 5m]. Thus, sixteen trees (or groups of trees) were sampled during each sampling date. The four tree species, selected on the basis of previous studies on warbler foraging activity in Travis County, were the dominant trees at both sites. They were *Juniperus ashei, Quercus virginiana (=fusiformis), Quercus buckleyi* (= *texana* of Correll and Johnson), and *Ulmus crassifolia*. Most of the junipers, especially at the Long Hollow site, were less than 5 meters, and those above 5 meters in height had closed crowns that were difficult to sample.

Invertebrates were sampled directly from the trees by sweep nets and beating sheets, standard techniques for sampling arthropods. Destructive sampling methods (such as pruning) are also commonly used, but are inappropriate for such sensitive habitats. Sampling with sweep nets and beating sheets is the most effective non-destructive method for directly sampling the branches and leaves on which the birds forage. More efficient sampling techniques that are capable of capturing larger numbers of insects per unit effort over time tend to over-emphasize insects flying through the habitat that may not be normal prey items of warblers foraging primarily on vegetation.

We took equal numbers of sweep and beat-sheet samples from each tree to facilitate comparisons. Each sweep sample consisted of eight sweeps. For each beating sheet sample, two separate branches were selected from different parts of a tree and each branch was shaken twice to dislodge invertebrates from the outer limbs and foliage onto the beating sheet. Access to upper levels of the trees was accomplished by nets with extension poles. We took two samples from each tree at both lower and middle heights and a single large sample from the upper canopy (due to the limited amount of foliage above 5 m on most trees), giving a total of 80 subsamples for each collection date.

We also collected some larval Lepidoptera (caterpillars) to rear in the laboratory since larvae are difficult to identify and adults are seldom collected in direct association with their host plant. Most such material came from supplemental collections, rather than from the regular biweekly samples. Additional supplemental collections were made using Malaise Traps at Long Hollow in 1993 for comparison with the species list based on the regular biweekly sampling program. Malaise traps are passive devices that intercept insects flying through the habitat, and collect both nocturnal and diurnal species.

Warren Pulich kindly made available to TxDOT the stomach samples he reported on in his classic study of the GCWA (Pulich, 1976). We examined these and compared them with the stomach contents of two other warbler species that were loaned to us for this purpose by Dr. Keith Arnold from the Texas Cooperative Wildlife Collection at Texas A&M University.

SAMPLE PROCESSING AND IDENTIFICATION

Sweep samples with plant debris were placed directly into zip lock bags containing ethyl acetate. Individual arthropods removed from beating sheets and nets were placed in vials with either alcohol or larval fixative. Sweep samples were stored in a freezer until they could be sorted from the plant debris. Sorting was done under a dissecting microscope to avoid loss of small arthropods such as mites, thrips, and chalcidoid wasps.

Delicate arthropods such as spiders, mites, and various immature stages are permanently stored in alcohol, whereas thrips are slide-mounted. All others are pinned or point-mounted. All specimens are labeled by locality, date, tree species, and sample height. Collaborators from the Department of Entomology, Texas A&M University, were responsible for nearly all of the identifications. Ed Riley, who currently handles all extension entomology identifications for the state of Texas, coordinated the curation and identification. Allen Dean provided identifications for the spiders (our largest group), and Charlie Cole identified all the thrips. Faculty members Horace Burke, Joseph Schaffner, Robert Wharton and James Woolley each took responsibility for providing identifications in their areas of expertise. Certain groups [most notably mites (Acari), midges (Nematocera), and many of the bark lice (Psocoptera)] were largely unidentified beyond these broader categories because the amount of time that would have been required to obtain authoritative identifications at the generic or species level would not have been cost-effective. Representatives of each species have been saved as voucher specimens in the Insect Collection of the Department of Entomology, Texas A&M University.

RESULTS

Results are provided in Appendices A-C, Table 3, and Figures 1-72. These lists and figures include only those arthropods collected with sweep nets and beating sheets during the regular biweekly sampling periods described above. Data from supplemental collections are not included. Tables 1 and 2 show sampling dates for 1993 and 1994, respectively.

A complete list of the species of invertebrates collected in our biweekly samples is provided as Appendix A. This list is arranged alphabetically by arthropod order, with each family, genus, and species also listed alphabetically under their respective higher categories (depending on the level of identification completed). Also included in this list is the total number of specimens collected for each taxon during the two year period of this study. We collected slightly more than 50,000 arthropods, about 33,000 of which were insects. More than 1600 species were represented in the samples.

Appendix B provides a breakdown of major invertebrate groups by tree (Ja = *Juniperus*; Qt = *Quercus buckleyi*; Qv = *Quercus virginiana*; Uc = *Ulmus*) and height category (U = >5m, M = 3-5m, L = 0-3m). As in Appendix A, the invertebrates are listed alphabetically by order, family, genus and species, with some of the smaller orders lumped together on one page at the end of the appendix. For major orders and some of the more important family groupings, these data have also been provided in pictorial form as bar graphs (Figures 1-19). Bar graphs represent only those 1994 samples taken with the same sized net at all three heights (a smaller net was used for the sweep samples at 0-3 m in 1993). Most of the identifiable species collected were represented by small numbers of individuals, thus giving few clues as to their preferences by height and tree species. This is a typical pattern for insects, with most species in any given habitat existing at relatively low population levels. For certain key groups represented largely by immature forms, however, the problem was one of identification at the species level. We collected large numbers of immature spiders, caterpillars, and leafhoppers, and these were frequently identifiable only to genus or family. Since all three are important elements in the diet of GCWA, based on the analysis of the gizzard samples from Pulich, we have combined these data by genus or family in some of the figures in order to facilitate discussions.

Appendix C presents phenological data. Sites (L = Long Hollow; S = Shellberg) and dates of collection are listed for each species, together with the total number of specimens collected per species on that date at that site. Seasonal activity has been graphed separately for each of the major orders (Figures 20-35) as well as for many of the species for which we had collected at least 50 individuals (Figures 36-72). These graphs provide a better picture of differences between years and between sites. A few of the collecting dates in 1993 were the same as those in 1994; others deviated slightly between years due to inclement weather, but were aligned by sample sequence for the graphs.

Table 3 shows a list of the arthropods found in the samples received from Warren Pulich. Although the arthropods in these samples were badly fragmented (as was typical of other warbler species examined for comparison), we were able to identify a number of additional taxa based in part on the collections from Travis County.

DISCUSSION

I. Species Composition

There were more than twice as many spiders (Araneae) in the samples than any other comparable group of invertebrates. The most numerically abundant insect groups were the Hymenoptera (wasps, ants, bees), Homoptera (leafhoppers, etc), Psocoptera (bark lice), and Coleoptera (beetles), respectively. Between 4500 and 5500 individuals were collected in each of these orders. Lepidopteran larvae represented only about 4% of the individual arthropods in our sweep net and beating sheet samples.

Although the totals may seem impressive, our individual samples were actually relatively small, and should in no way be interpreted as reflecting the total number of individuals that are available to the GCWA at these sites. For example, a single Malaise trap set in a stand of Texas Oak at the Long Hollow site during the period from 23 April to 8 May, 1993 captured 8684 insects. This nearly equaled the total number of insects taken during all of the biweekly samples at the Long Hollow site in 1993. Malaise traps are specifically designed to sample flying insects, and this sample thus had large numbers of flies and wasps. There was also a large number of adult *Croesia* and *Sparganothis*, tortricid moths that were exceptionally abundant as caterpillars on Texas Oak in mid April.

The remains of 184 individual arthropods were identified from the contents of the 22 GCWA gizzards obtained from Warren Pulich. A wide diversity of taxa were represented in these samples. Lepidopteran larvae (primarily Geometridae) were found in 68% of the samples, and accounted for 22.4% of the recognizable individuals. This was by far the largest group. Next in abundance were spiders, beetles, Hymenoptera, and Homoptera, each representing 14-15% of the recognizable individuals. Ten percent of the individuals were termites, but these were confined to a single sample.

Analysis of these samples confirms that GCWA is a generalist, with a highly varied diet. One gizzard, for example, contained 19 recognizable individuals representing at least 14 species in 7 arthropod orders. The arthropods varied greatly in size, from midges and wasps about 1-2mm in length to a large sphingid caterpillar over an inch long. The one sample with 18 pairs of termite wings supports the hypothesis that GCWAs are capable of keying in on those prey that are locally abundant. Termites tend to have only one or two flights per year, generally lasting a day or two. For GCWA, they would thus be available on a one-time-only basis. During the course of our investigations, GCWAs were observed feeding once each on the following insects: a moth, caterpillars (Tortricidae: *Croesia semipurpurana*), and a katydid (Tettigoniidae).

Based on the analysis of these samples from Pulich, as well as the observations made on foraging behavior by Pulich (1976) and others, we feel confident that the sweep net and beating sheet samples are representative of the potential prey available to the warbler. In general, there was a good match between the insect groups represented in the biweekly samples and those found in the stomach samples. With the exceptions of Lepidoptera and Psocoptera, the groups of arthropods that we collected most commonly were the ones best represented in the gut samples. Lepidopteran larvae were numerically dominant in the gut samples that we analyzed, but were usually less commonly encountered than other groups in our biweekly samples. An outbreak of tortricid moths on Texas oaks provided large numbers of larvae in the April samples at Long Hollow in 1993. These species were much less abundant in 1994, however. Psocoptera were one of our most commonly collected groups of insects, especially in 1994, but were not detected among the arthropod remains in the Pulich samples. Psocoptera are small, very soft-bodied insects, however, and simply may not have been preserved well enough to afford recognition.

While analysis of gut contents provides valuable clues as to the range of prey types taken by GCWA, quantitative analysis of gut samples is risky both because of the warbler's ability to dismember prey before ingesting (Pulich, 1976), and because of the fragmentation and differential digestability of the prey items.

Preliminary data on two other *Dendroica* warblers provide an interesting contrast with GCWA. One species (contents of 3 gizzards, taken from the same Presidio County locality on consecutive dates) fed almost exclusively on Reduviidae (Hemiptera). The second species (contents of 4 gizzards from the same locality as the first species but 2.5 months earlier) fed largely on beetles.

II. Preferences by Height and Tree Species

At the ordinal level, several arthropod groups were collected much more commonly at lower levels (0-3m) than at either mid or upper canopies. Groups showing this pattern include mites, spiders, Collembola, Hemiptera, Hymenoptera, Neuroptera, Orthoptera, and polyxenid millipedes (see Figures 1-19). For the Hemiptera, geometrid larvae, Neuroptera, Orthoptera, this pattern was largely confined to juniper (Figures 6, 14, 16, 17 respectively), and was not evident on other tree species. The pattern in Neuroptera (Figure 16) was due exclusively to members of the family Coniopterygidae. The pattern in Orthoptera (Figure 17) was due to nymphal crickets. Among arachnids, the preference for lower levels was much more pronounced for mites than for spiders, but the large numbers of spiders collected suggest that this was still a significant trend. Though not reflected in Figure 1, which shows only half of the 1994 data, we collected nearly twice as many mites on junipers and elms as on oaks.

Several interesting trends were evident in the insect data. As with mites, Collembola and Cicadellidae (leafhoppers: see Figure 8) were much more commonly collected on junipers and elms than on oaks. Psocoptera were collected predominantly on juniper. The results for lepidopteran larvae were strongly influenced by differences in populations between 1993 and 1994. The 1993 collections were dominated by tortricids and gelechiids from mid and upper levels on Texas oak, and by a single species of tortricid on juniper with no apparent height preferences. Populations of tortricids were much reduced in 1994, leading to stronger representation of geometrids, which were most commonly collected at lower heights on juniper (Figure 14). This example shows how the overall picture of height preferences of a particular category of arthropods (in this case caterpillars) can change between years.

Those arthropod species that were collected in large numbers tended to show distinct preferences for certain tree species, but rarely for any particular height on the tree. A few of the more commonly collected species are discussed here, including those with height preferences; additional examples can be found in Appendix B. Members of the genus *Xanthonia* (Chrysomelidae) were among the most commonly collected beetles in our samples. At least five species were collected, three of these in large numbers. Species 1 was collected primarily from elms, species 2 almost exclusively from junipers, and species 3 from oaks (mainly live oak). Thus, taken together, *Xanthonia* species were distributed fairly uniformly by both height and tree species in the GCWA habitat. Looking at other commonly collected arthropods, we found two beetles of the genus *Hyperaspis* (Coleoptera: Coccinellidae), one chrysomelid and one cicadellid (Homoptera) that favored mid and/or upper canopies, two species of *Mordellistena* (Coleoptera: Mordellidae) and a different chrysomelid that preferred lower heights. Junipers were favored by at least two species of spiders, three beetles, one fly, two leafhoppers, one issid (a homopteran found in some of the gizzard samples from Pulich), one lygaeid, two mirids, and six parasitic Hymenoptera. Elms were preferred by at least three beetles (belonging to Buprestidae, Coccinellidae, and Curculionidae), two flies, one ant, two parasitic Hymenoptera, and several homopterans. There were several insect species that shared preferences for oaks and elms to the virtual exclusion of junipers (the homopteran *Metcalfia pruinosa*, Figure 10, is a typical example). There were also several species in all the major orders that preferred oaks (mainly Texas oaks). Although most of the species that were collected in sufficient number for analysis exhibited decided preferences for a single tree species, there were several spiders, one beetle, one assassin bug (Reduviidae), and one homopteran that showed no preferences. Fire ants similarly showed no preferences.

Previous work on warbler activity suggests that these birds spend large portions of their time in the upper levels of the trees (Beardmore, personnel communication), and commonly forage there (Pulich, 1976). Our collections suggest that the fauna of the upper canopy is no different qualitatively than that of the mid and lower levels. It appears that there may be more arthropods at lower levels than at upper levels, but this needs verification. In any case, there is certainly no lack of potential prey items at any height on any of the four tree species sampled.

III. Phenology

Arthropods increased significantly in abundance through early April, increased dramatically in late April, then decreased somewhat and remained more or less stable through June with just two exceptions: 1) The late March sample in 1993 contained an enormous number of thrips, nearly equal to all other arthropods collected on that date; 2) Instead of the increase in late April seen in 1993, there was a pronounced decrease in abundance at this time in 1994. Seasonal patterns were distinctive for each taxon, with overall similarity in total numbers of arthropods collected from one sampling period to the next resulting from increases in one taxon at the expense of another on any given sampling date. Further, some taxa showed considerable differences between years and even between sites, while others did not.

Spiders, the order with by far the largest number of individuals, showed a steady increase in numbers through the season at both sites and in both years (Figure 21), and were the only major group to show this pattern. (Most other groups had populations that peaked earlier in the season, and then decreased to varying degrees by the end of the sampling period.) For spiders, the seasonal patterns for individual species or groups of species was somewhat more variable than the overall trend. *Oxyopes scalaris* (Figure 40) and species of *Hibana* and *Philodromus* (Figures 36 and 41) show roughly the same gradual increase through the season as spiders in general. *Ceratinopsis purpurescens* and *Oxyopes salticus*, however, both had sharp peaks of abundance in late March/early April (Figures 37 and 39). Populations of *Misumenops* generally showed a broad, mid-season peak of abundance, followed by an end-of-season depression (Figure 42). There were distinct differences between years in both *Misumenops* and *Hibana*. For *Misumenops* (Figure 42), the populations peaked earlier in 1993, and dropped off more precipitously towards the end of the season. For *Hibana* (Figure 36), the end of season peak was greatly depressed in 1994 relative to 1993.

Though less abundant as a group at the beginning of the season than at the end, spiders were nevertheless one of the few groups available as prey when the warblers arrived in their central Texas breeding grounds in 1994. Smaller numbers of Diptera and Hymenoptera were also present at this time, as were Collembola and mites. Collembola and mites, though on the small end of the scale in terms of available prey items, are nonetheless within the size range of arthropods taken by GCWA.

Coleoptera (beetles) as a group were most abundant in April at both sites and in both years (Figure 22). Populations tapered off strongly over the last half of the season. This same general pattern was also evident in Diptera, Lepidoptera larvae, Thysanoptera (thrips), and to a lesser degree, Hymenoptera. Eighteen species of Coleoptera were collected in sufficient numbers to provide some assessment of their availability relative to the warbler's breeding cycle (Figures 43-60). Nearly all of these species showed pronounced peaks of activity either in April or late March, then disappeared by June. The aderid *Ganascus ventricosus* (Figure 43) was exceptional in showing a peak of activity at the end of the season. Though most of the beetle species had discrete periods of activity, several species were active all season long, or nearly so. These included the long-lived coccinellid predators and one of the weevil species (Figures 55-58). The numbers collected per species differed considerably from one year to the next for some species but not others. Differences, when they occurred, were not consistent across the species. Thus, *Ganascus ventricosus*, *Anthaxia viridifrons*, two species of *Cantharis*, *Xanthonia* spp. 2 and 3, *Phyllobaenus humeralis*, and *Glyphonix* sp. (Figures 43-46, 52-54, and 59) were more abundant in 1994 than 1993. However, four species of Chrysomelidae (including *Xanthonia* sp. 1) and one Scaptiidae were much more abundant in 1993 than 1994 (Figures 48-51, 60). Site differences were most obvious for *Xanthonia* sp. 3 (Figure 53) and *Glyphonyx* sp. (Figure 59), which were particularly abundant at Shellberg, and *Spintherophyta globosa* (Figure 50) which was not collected at Shellberg.

More flies were collected in 1993 than 1994, and the pattern was somewhat different between the two years (Figure 24). Empididae, Chloropidae, and Nematocera contributed significantly to the 1993 peak in late April, whereas the peak in early April was due primarily to Empididae, Lauxaniidae and Nematocera (Figures 61-64). In 1994, however, few flies were collected in late April, and the early April peak, seen only at the Long Hollow site, included only a few lauxaniids and midges (Nematocera).

Hemiptera (Figures 25 and 26) were collected in larger numbers at the Long Hollow site than at Shellberg. The peak in 1993 was in late April, and fairly discrete, but the peak at the Long Hollow site in 1994 extended from early April to early June. A more discrete peak occurred at the Shellberg site in early May. The peaks were the result of relatively few species collected in large numbers (e.g. the mirids *Atractotomus miniatus*, *Lygocoris quercalbae*, and *Tropidosteptes quercicola*, primarily on oaks).

Except for two pronounced peaks in late March and late April of 1993, both due to large numbers of membracids collected on these dates, Homoptera (Figures 27 and 28) were generally available as prey in moderate numbers throughout the season. A nearly identical pattern occurred in the Hymenoptera (Figure 29). Unlike the Homoptera, the Hymenoptera were remarkably diverse, containing far more species than any other order of arthropod collected during the two years of the study. The bulk of the collections were of parasitic Hymenoptera, which have immature stages that develop at the expense of other insects and spiders. (A high percentage of the caterpillars brought back to the laboratory were parasitized by parasitic wasps as well as by tachinid flies.) Most of the species of parasitic Hymenoptera were represented by few individuals. Figures 65 and 66 represent two of the more commonly collected species, which show typical patterns of multiple peaks of abundance. Ants were also very well represented in the samples, and were the most common group of Hymenoptera at the start of the season in 1994. Ants showed considerable variation in patterns of abundance, with early, middle and late season species (Figures 67-71).

The lepidopteran larvae in the samples were primarily leaf rollers in the families Tortricidae and Gelechiidae. This was particularly true for 1993, when there was an outbreak of the tortricid *Croesia semipurpurana* on Texas oak. The large peak in late March and early April was due largely to this species, though there were also numerous geometrid (inchworm) larvae at this time (Figure 72), as well as the beginning of an infestation of the tortricid *Cudoniger hustonana* on junipers. Tortricid and gelechiid caterpillars are highly motile and semi-concealed, and may be difficult to catch. As noted in the literature, however, they often pupate in the leaf rolls and are much more readily captured as pupae. Geometrid larvae, commonly encountered in the gizzard samples from Pulich, are exposed and thus commonly encountered by foraging birds. They are, however, very cryptically colored.

Orthoptera, Psocoptera, and polyxenids (very small millipedes about the size and shape of a carpet beetle larva) all had roughly similar patterns of abundance in late May and June (Figures 32-34). Together, they comprised a very significant portion of the available prey during this period. The crickets and katydids (Orthoptera) were more abundant during this period in 1993, when polyxenids were essentially absent. The Psocoptera were much more prevalent in 1994 than 1993.

Summary of Seasonal Availability of Potential Arthropod Prey, 1993/1994

March 1st: Spiders from 6-7 different families equally abundant on all trees; ants, flies, Collembola, and mites also present, but in much fewer numbers (1994 totals, site not approved in time for sampling in 1993).

Mid-March: Spiders (several families, uniformly distributed on tree species), mites, and Homoptera (mainly membracids on oaks) all equally abundant in 1994 (site approved too late in 1993 for adequate samples).

Late March: Thrips were by far the most abundant group, nearly all on oaks. Thrips, however, are very small and flat and at the lower end of the size scale of prey available to GCWA. Otherwise, in 1993, caterpillars, Homoptera, spiders, and Hymenoptera were all much more abundant than the dominant groups in mid-March. Spiders and beetles, on the other hand, were the dominant groups in 1994. Though spiders were again more or less uniformly distributed by tree species, oaks were by far the most productive (even when thrips are excluded) in 1993 because of the concentration of caterpillars and membracids. In 1994, there were fairly large numbers of one of the *Xanthonia* species (Coleoptera, Chrysomelidae) on juniper.

Early April: Caterpillars (mainly on oaks) and beetles (more uniformly distributed) were the dominant groups in 1993, followed by spiders and flies. In 1994, beetles were the largest group, followed by the less abundant spiders and Hymenoptera. Caterpillars were relatively insignificant in 1994. Spiders were somewhat more commonly collected on *Quercus virginiana* during all of April.

Late April: Homopterans, primarily membracids on oaks, were the dominant group in 1993. More or less equal numbers of flies, Hemiptera, Hymenoptera, and spiders were also abundant. Flies and Hemiptera (mainly Miridae) were largely on oaks. Large numbers of adult tortricids (the product of last month's caterpillars) were seen whenever understory plants were disturbed, but were not very abundant in our sweep samples. In 1994, beetles, spiders and Hymenoptera were the most abundant groups.

Early May: Many groups were more or less equally abundant during this period. Spiders, beetles, Hymenoptera, flies (mostly Chironomidae), and Homoptera dominated in 1993, and Spiders, Homoptera, Hymenoptera, beetles, and Psocoptera were the most abundant groups in 1994. Spiders and flies, at least, were more or less uniformly distributed by tree species, but a significant proportion of the Homoptera consisted of leafhoppers (Cicadellidae) on juniper in 1994.

Mid to late May: Spiders, uniformly distributed amongst tree species, were easily the most abundant group in 1993, followed by Homoptera and Hymenoptera. Psocoptera, mainly on junipers, dominated the collections in 1994, especially at Shellberg. Spiders were next in abundance, followed by Homoptera and Hymenoptera.

Early June: Once again Psocoptera were the most abundant arthropods collected in 1994, though the peak shifted from Shellberg to Long Hollow on this date. Spiders were the dominant group in 1993, with considerably more individuals than the next two most abundant orders combined. In 1994, spiders were nearly as abundant as Psocoptera.

Mid June: Spiders were overwhelmingly dominant in both years, with Psocoptera a distant second in 1994. Spiders were a little more abundant on junipers than on other tree species in 1993, and there were noticeably fewer spiders on Texas oak. The same patterns of host tree preference occurred in early June.

July: Spiders were the most abundant arthropods in early, mid- and late July samples, far exceeding all other groups collected. From late June through the end of July, spiders accounted for one-third to one-half of all arthropods collected on each sample date.

CONCLUSIONS

This study clearly demonstrates that large numbers of species, representing diverse arthropod orders, are available as prey to the golden-cheeked warbler in its preferred nesting habitat. The abundance of individual species varies markedly not only seasonally, but also from place to place, and from one year to the next. There are even noticeable within-site differences among trees on any given date.

The species list we have compiled provides a baseline for an understanding of the kinds of arthropods present in GCWA nesting habitat. The list, and the voucher specimens associated with it, can be used as reference for identification of specific prey items observed during studies of warbler foraging behavior. These data can also be used to focus on further studies of population fluctuations of individual species (e.g. *Croesia semipurpurana* or *Xanthonia* sp. # 2) or groups of species (e.g. geometrid larvae or leafhopper nymphs). The samples provide only a preliminary evaluation of the relative abundance of some of the more common species and groups of species. In order to assess populations quantitatively, more intensive sampling would have to be undertaken. Based on the variation noted above, it is unlikely that any particular arthropod species or even group of species can be consistently relied upon by the warbler, and this is confirmed by our reexamination of the stomach samples from Pulich.

FOOTNOTES

Any additional data and analyses that result from this study will be made available to TxDOT. We also anticipate several publications, including one on the species composition and phenology of the spiders collected during this program. Spiders are one of the few groups for which comparisons can be made with earlier studies in the Austin area (Frankie, et al. 1979), and the results of this study show some interesting differences.

REFERENCES

Frankie, G. W., J. M. Tucker, and J. B. Welch. 1979. Arthropod fauna of live oak in urban and natural stands in Texas: 1. Site descriptions, oak taxonomy, phenology and sampling methods. J. Kansas Entomol. Soc. 52: 71-85.

Pulich, W. M. 1976. The golden-cheeked warbler: a bioecological study. Bull. Texas Parks & Wildlife Department.

Figure 1

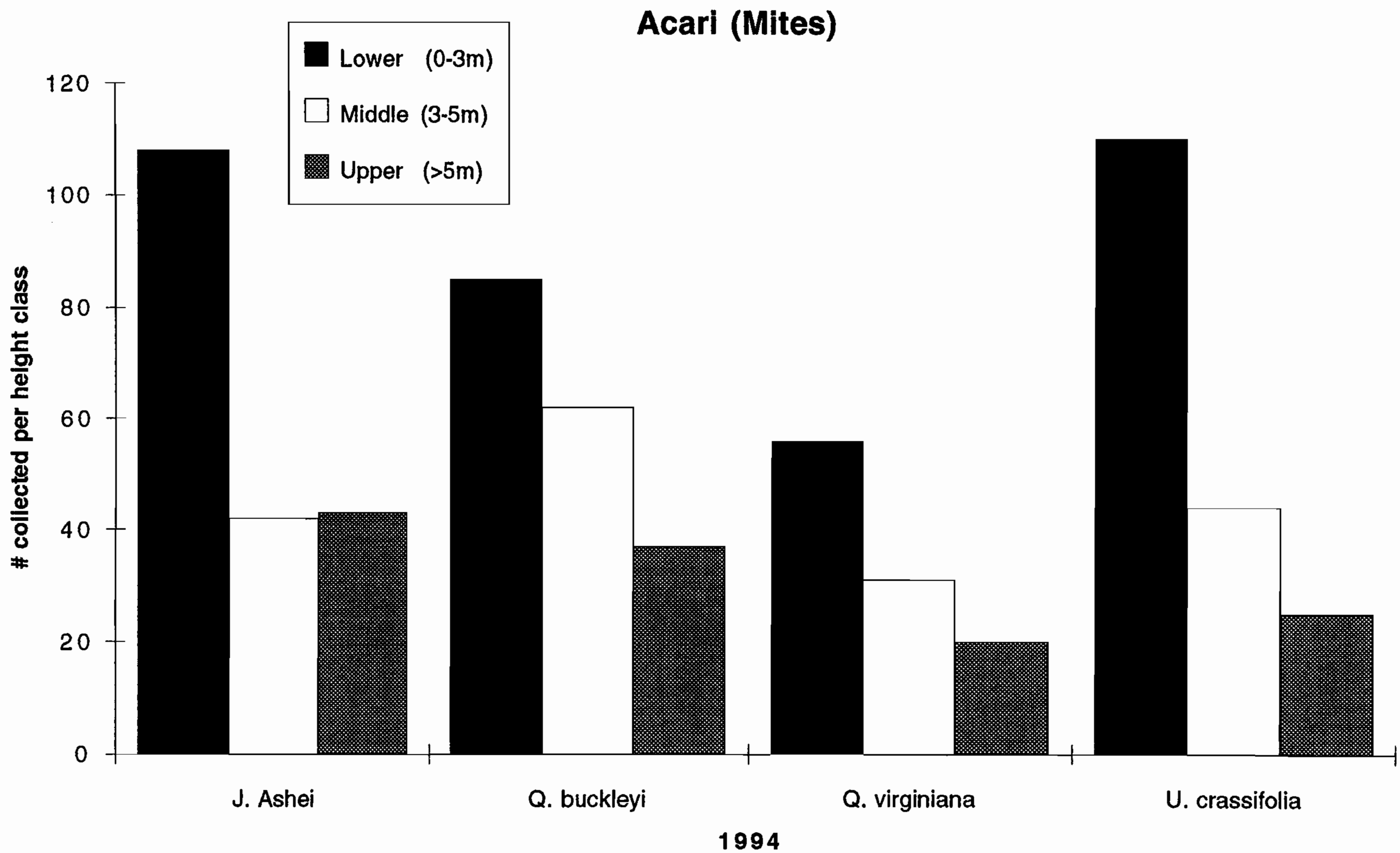

Acari (Mites)
Lower (0-3m)
Middle (3-5m)
Upper (>5m)
collected per height class
120
100
80
60
40
20
0
J. Ashei
Q. buckleyi
Q. virginiana
U. crassifolia
1994

Figure 2

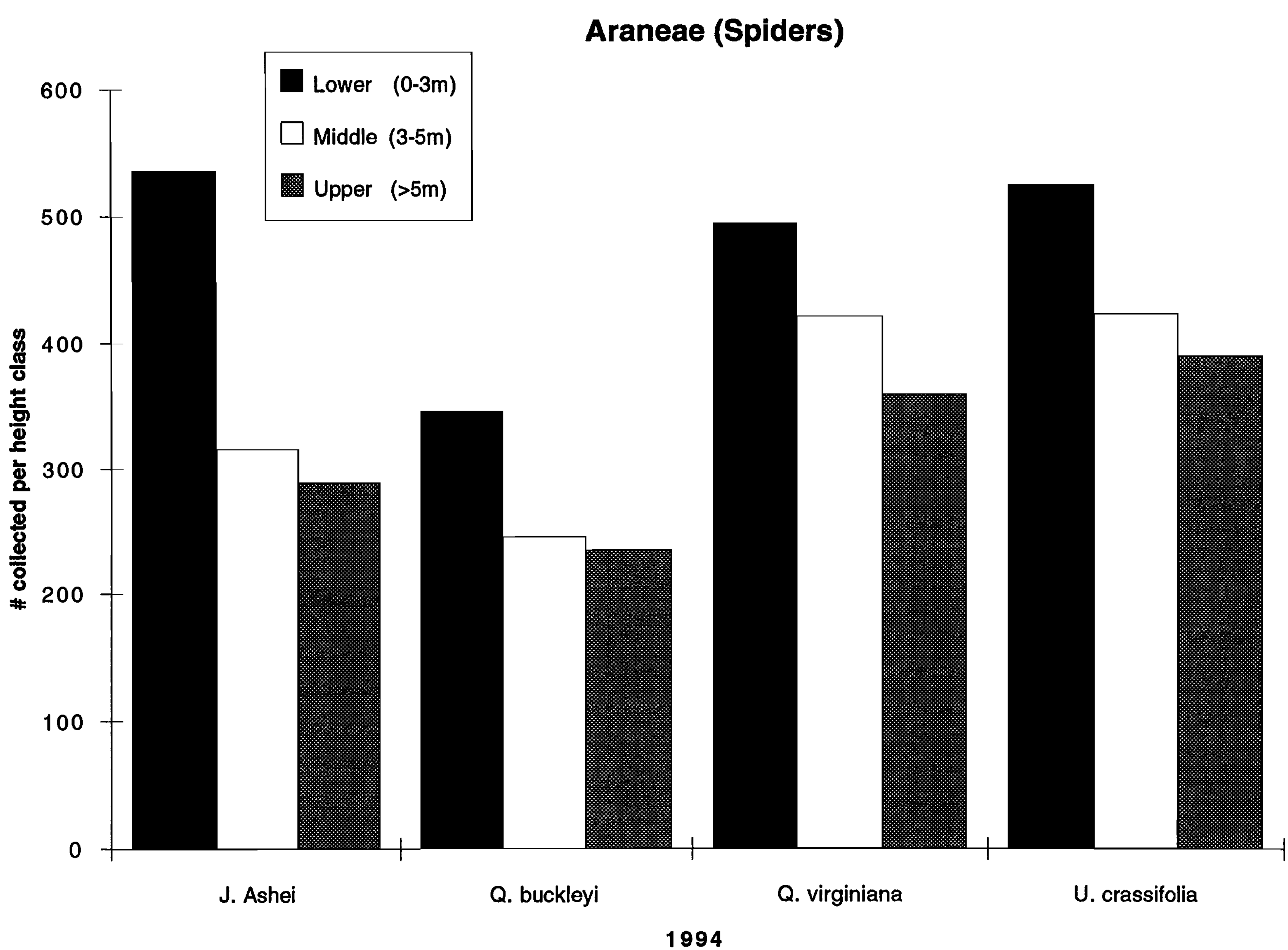

Araneae (Spiders)
Lower (0-3m)
Middle (3-5m)
Upper (>5m)
600
500
400
300
200
100
0
collected per height class
J. Ashei
Q. buckleyi
Q. virginiana
U. crassifolia
1994

Figure 3

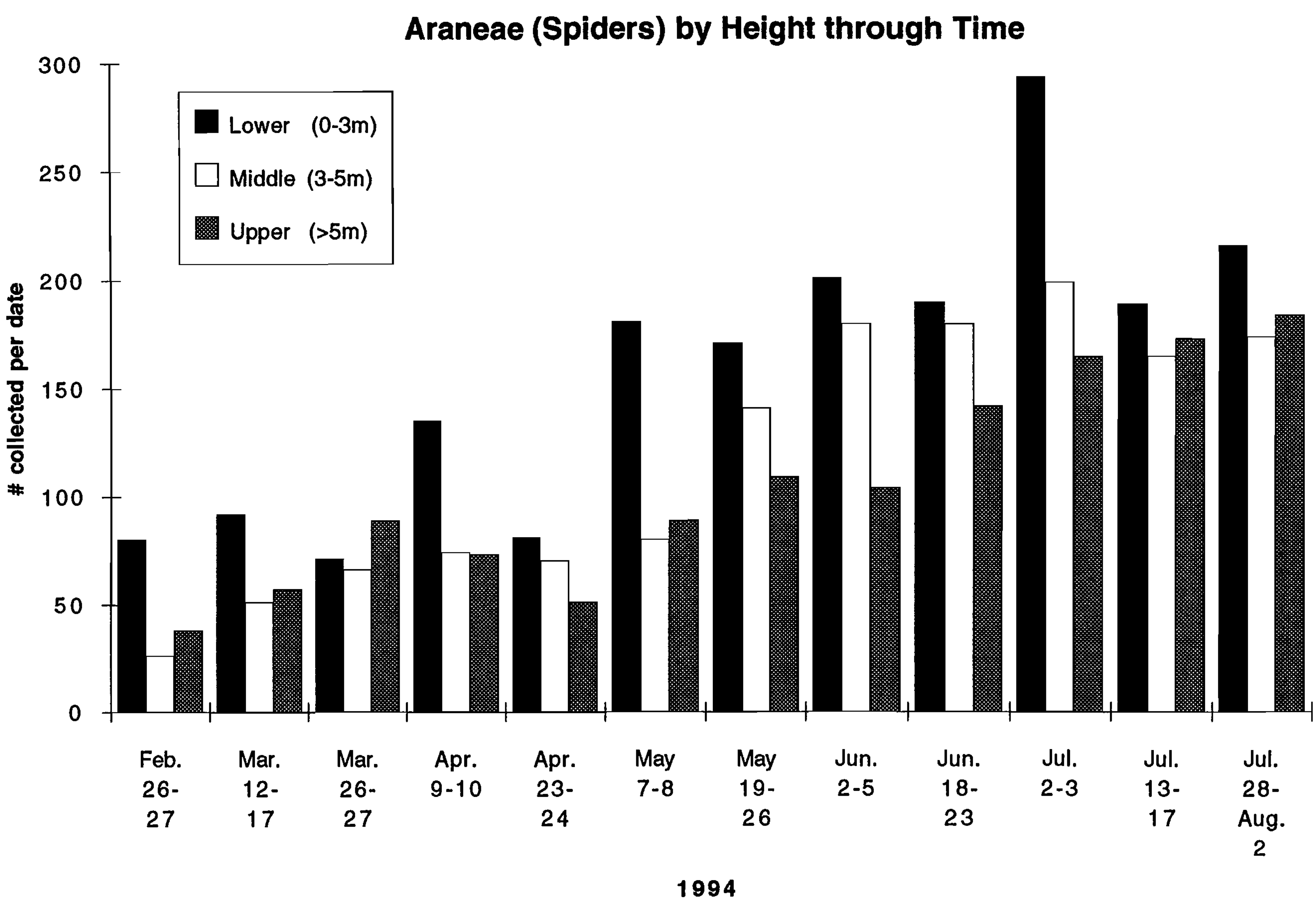

Araneae (Spiders) by Height through Time
Lower (0-3m)
Middle (3-5m)
Upper (>5m)
collected per date
300
250
200
150
100
50
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
1994

Figure 4

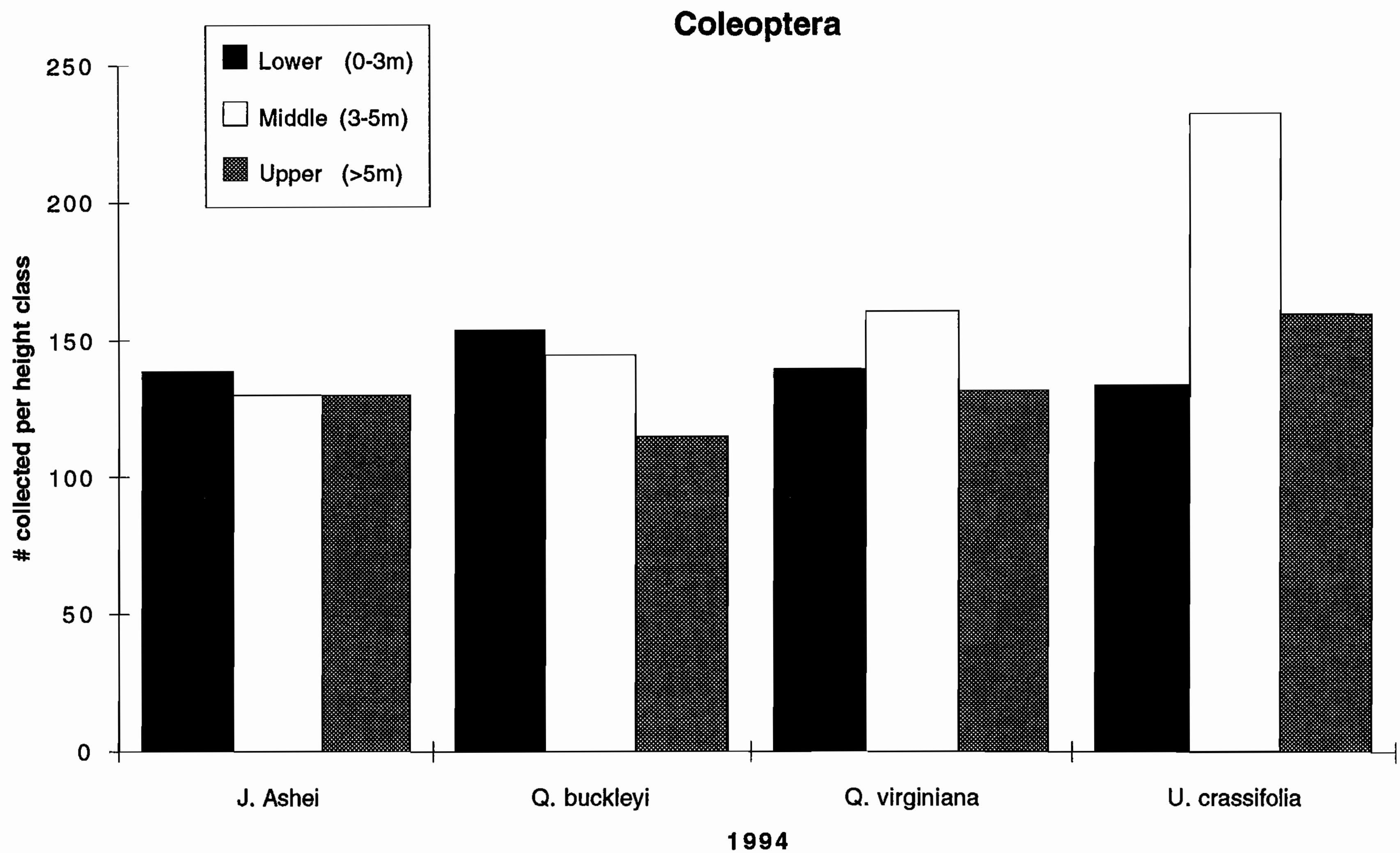
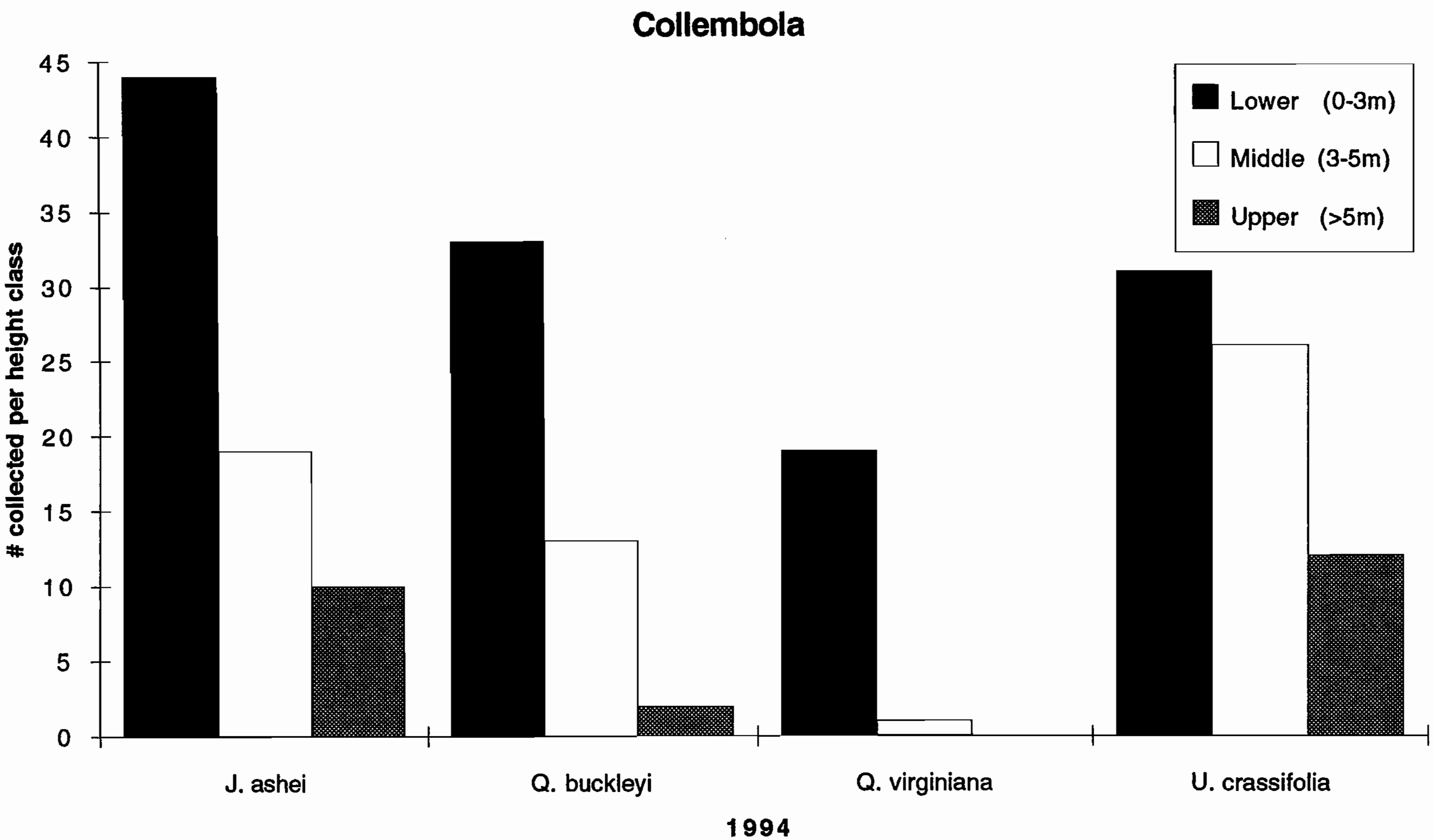

Coleoptera
Lower (0-3m)
Middle (3-5m)
Upper (>5m)
collected per height class
250
200
150
100
50
0
J. Ashei
Q. buckleyi
Q. virginiana
U. crassifolia
1994

Figure 5



Collembola
collected per height class
45
40
35
30
25
20
15
10
5
0
Lower (0-3m)
Middle (3-5m)
Upper (>5m)
J. ashei
Q. buckleyi
Q. virginiana
U. crassifolia
1994

Figure 6

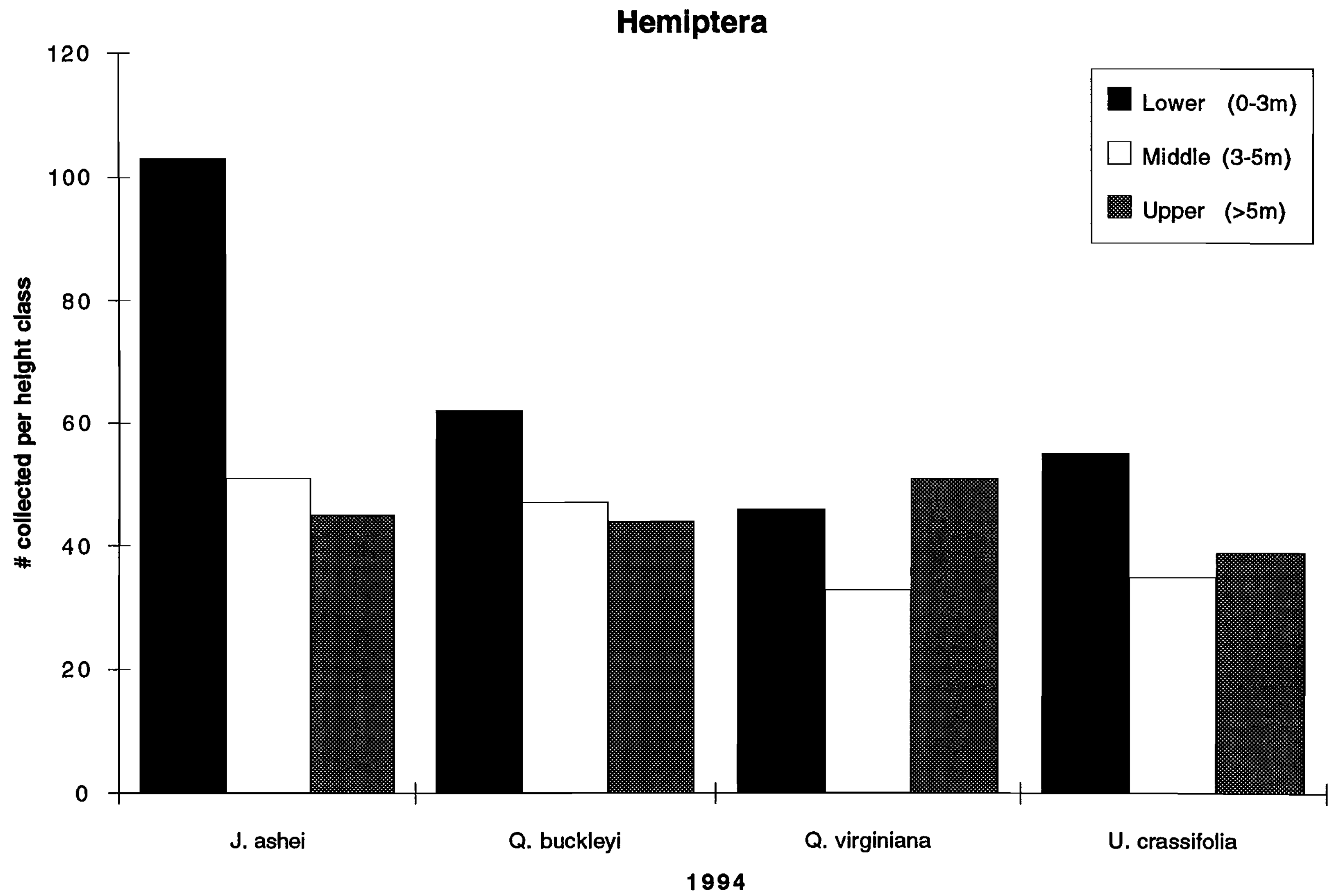

Hemiptera
120
100
80
60
40
20
0
collected per height class
Lower (0-3m)
Middle (3-5m)
Upper (>5m)
J. ashei
Q. buckleyi
Q. virginiana
U. crassifolia
1994

Figure 7

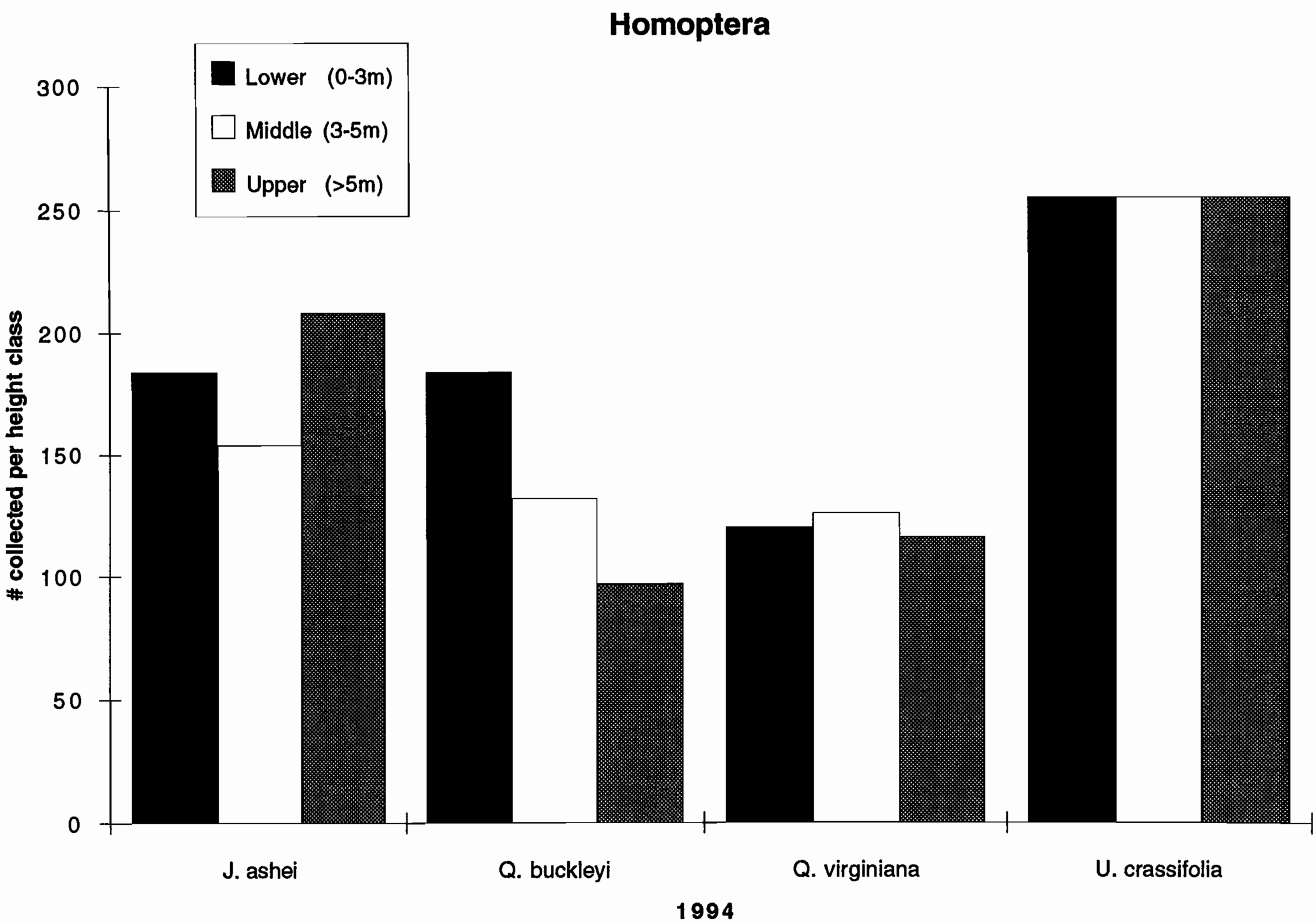

Homoptera
Lower (0-3m)
Middle (3-5m)
Upper (>5m)
collected per height class
300
250
200
150
100
50
0
J. ashei
Q. buckleyi
Q. virginiana
U. crassifolia
1994

Figure 8

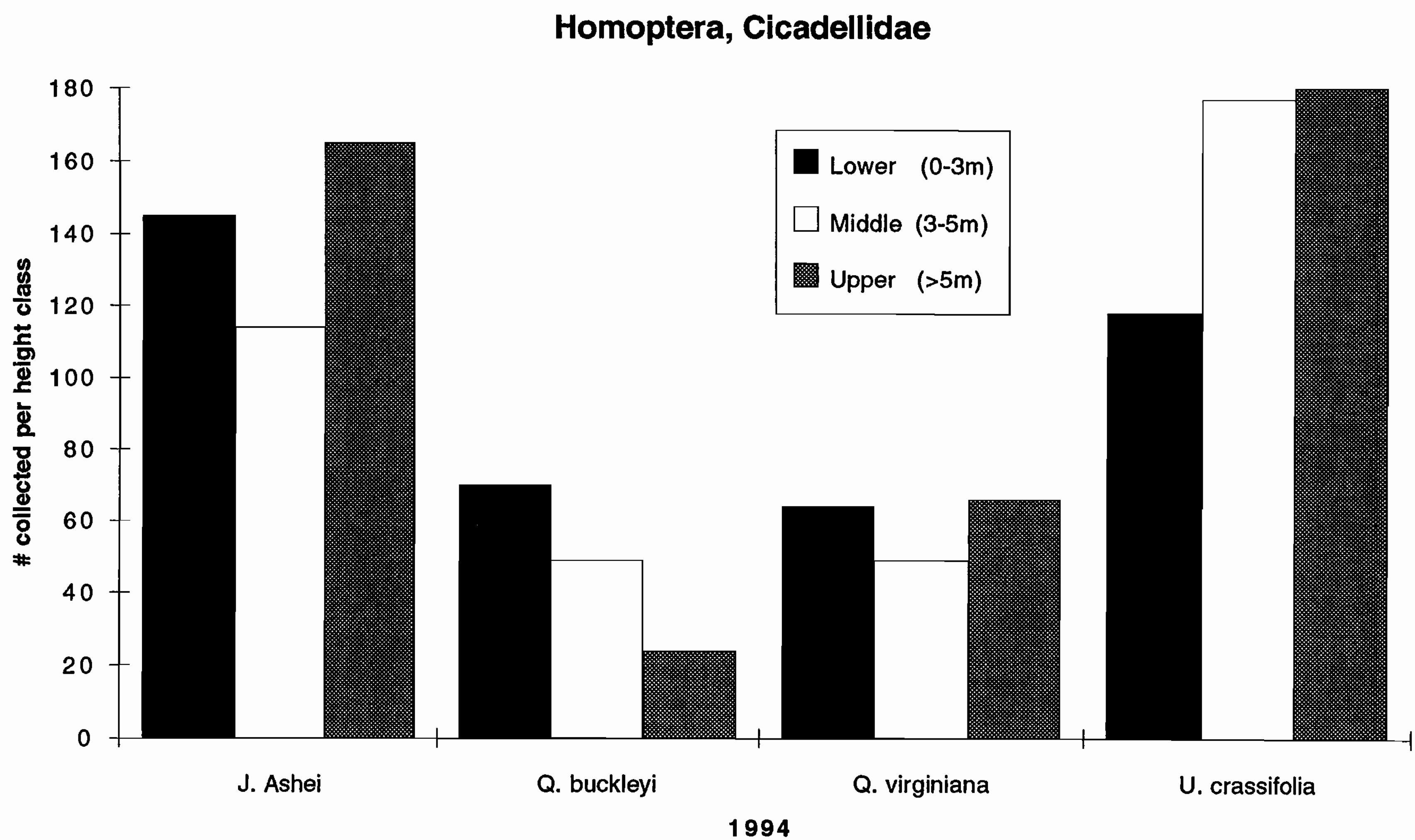

Homoptera, Cicadellidae
collected per height class
180
160
140
120
100
80
60
40
20
0
Lower (0-3m)
Middle (3-5m)
Upper (>5m)
J. Ashei
Q. buckleyi
Q. virginiana
U. crassifolia
1994

Figure 9

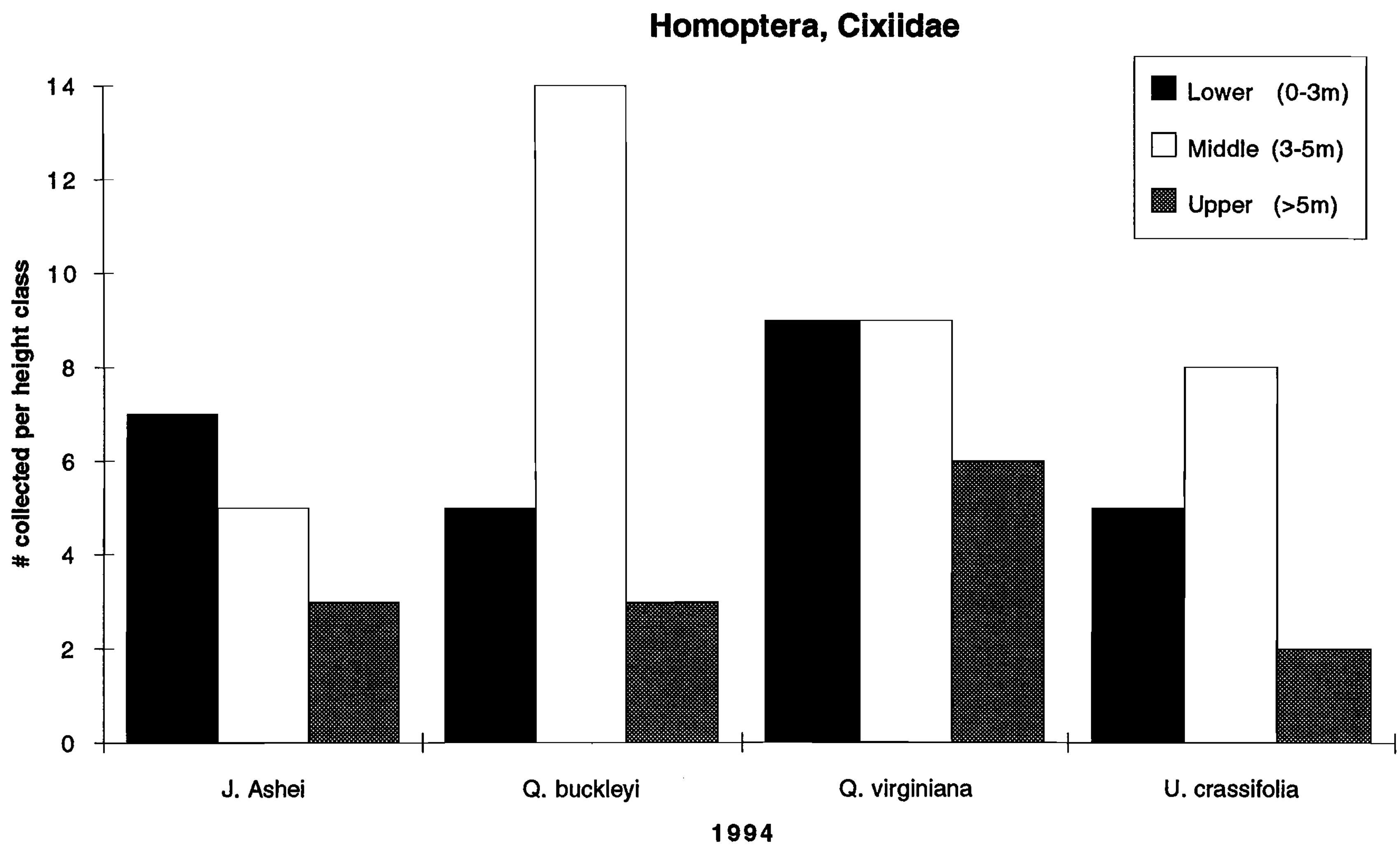
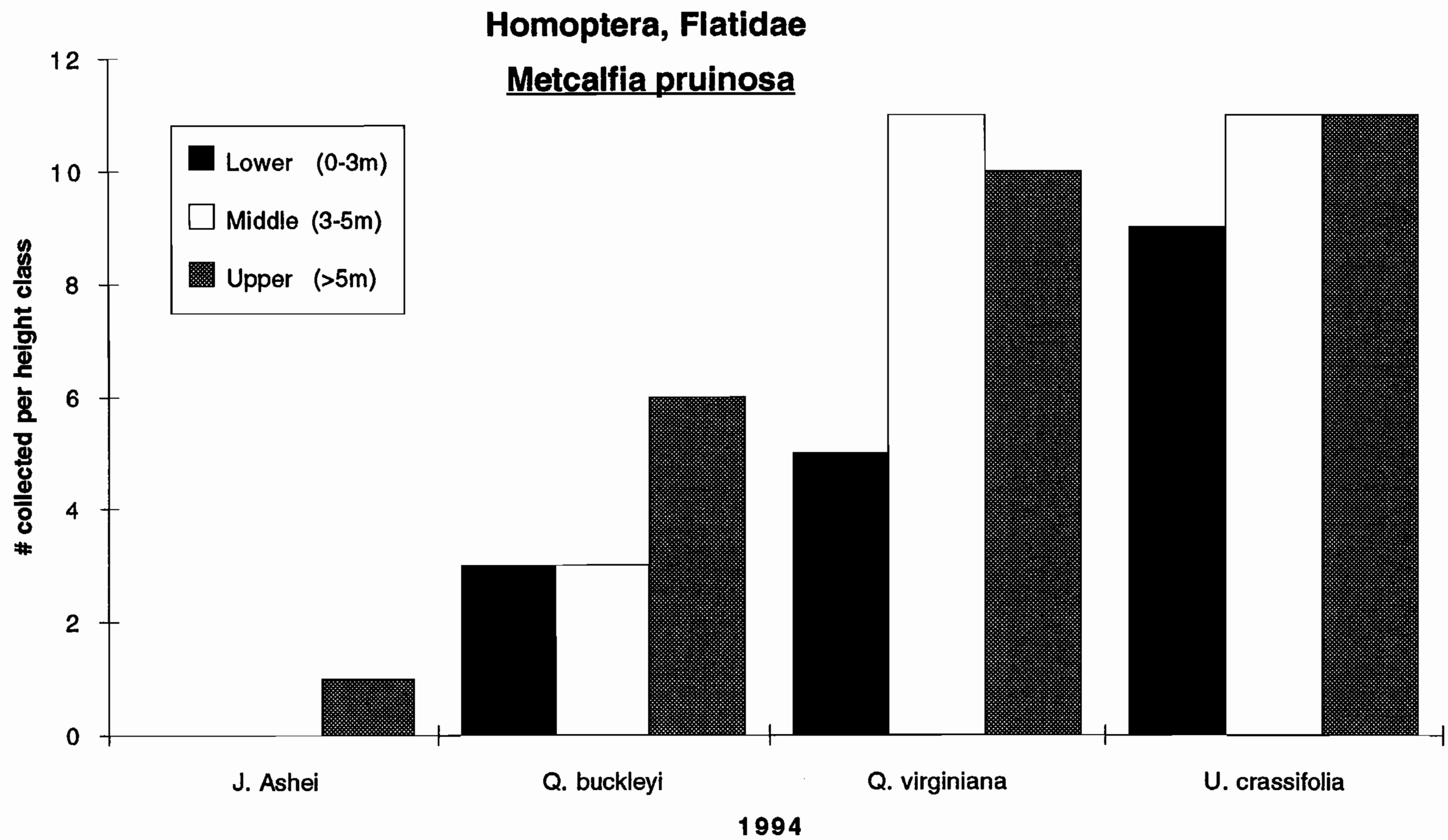

Homoptera, Cixiidae
Lower (0-3m)
Middle (3-5m)
Upper (>5m)
collected per height class
14
12
10
8
6
4
2
0
J. Ashei
Q. buckleyi
Q. virginiana
U. crassifolia
1994

Figure 10



Homoptera, Flatidae
Metcalfia pruinosa
Lower (0-3m)
Middle (3-5m)
Upper (>5m)
collected per height class
12
10
8
6
4
2
0
J. Ashei
Q. buckleyi
Q. virginiana
U. crassifolia
1994

Figure 11

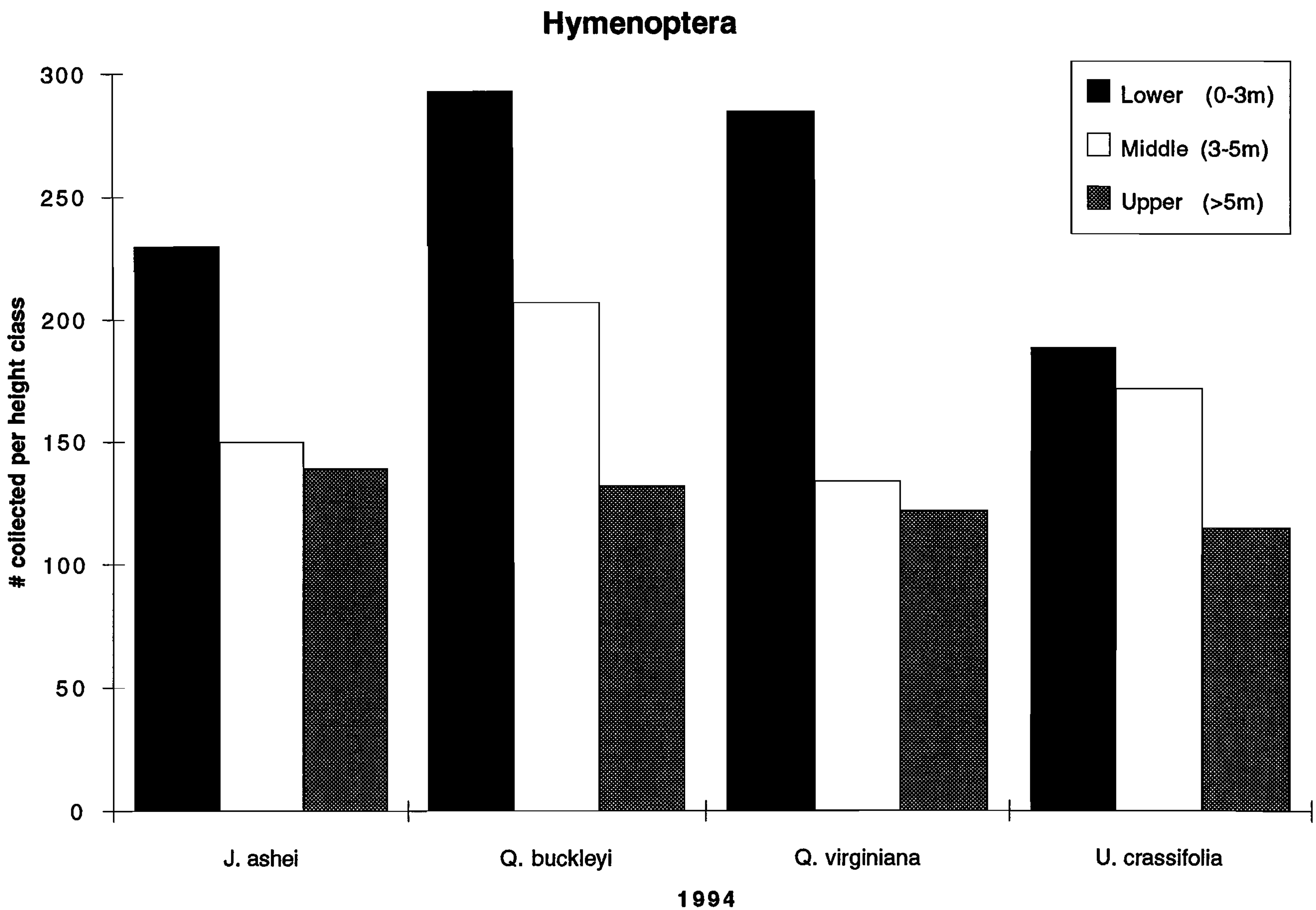
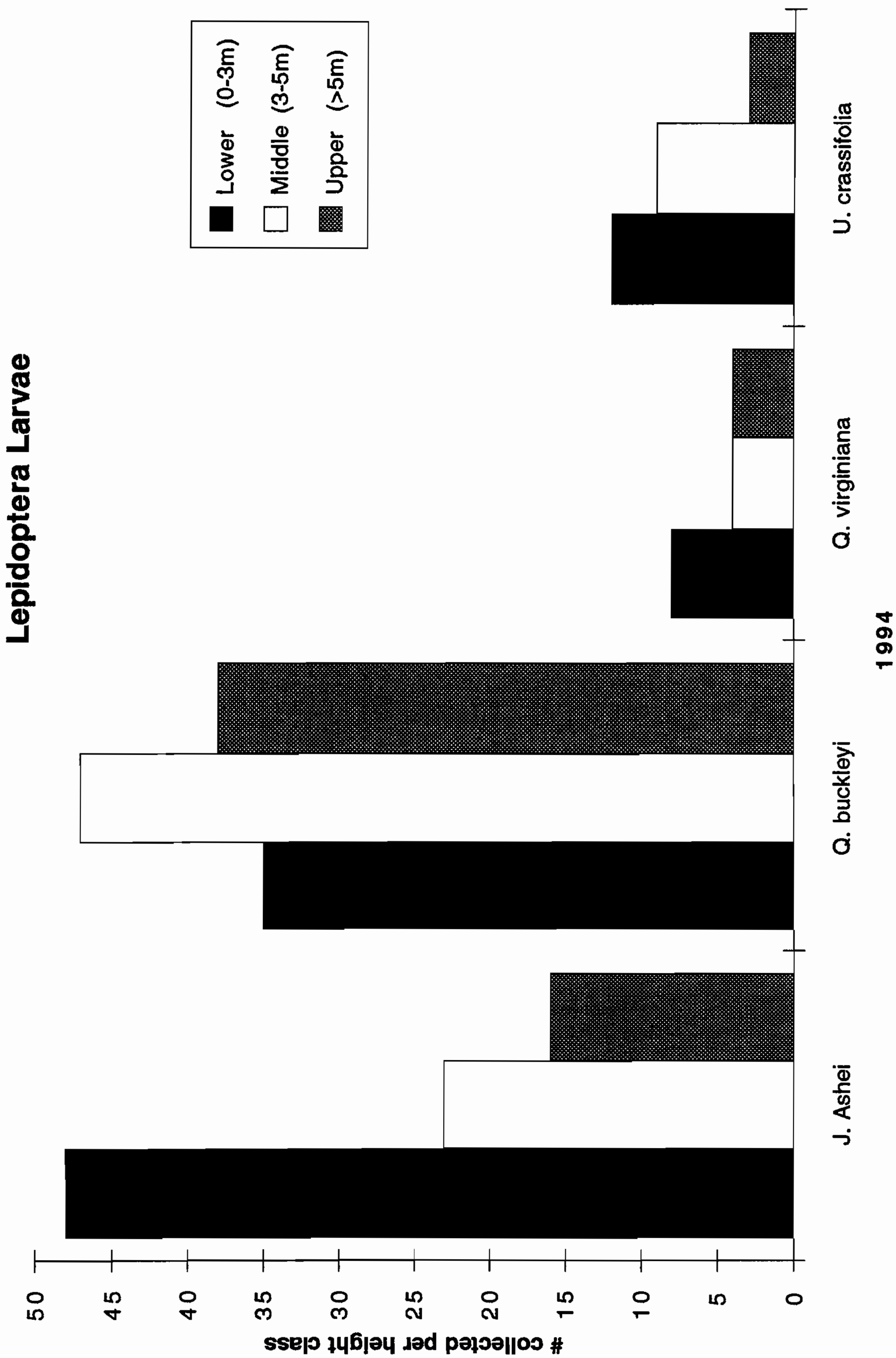

Hymenoptera
Lower (0-3m)
Middle (3-5m)
Upper (>5m)
collected per height class
300
250
200
150
100
50
0
J. ashei
Q. buckleyi
Q. virginiana
U. crassifolia
1994

Figure 12



Lepidoptera Larvae
collected per height class
50
45
40
35
30
25
20
15
10
5
0
J. Ashei
Q. buckleyi
Q. virginiana
U. crassifolia
1994
Lower (0-3m)
Middle (3-5m)
Upper (>5m)

Figure 13

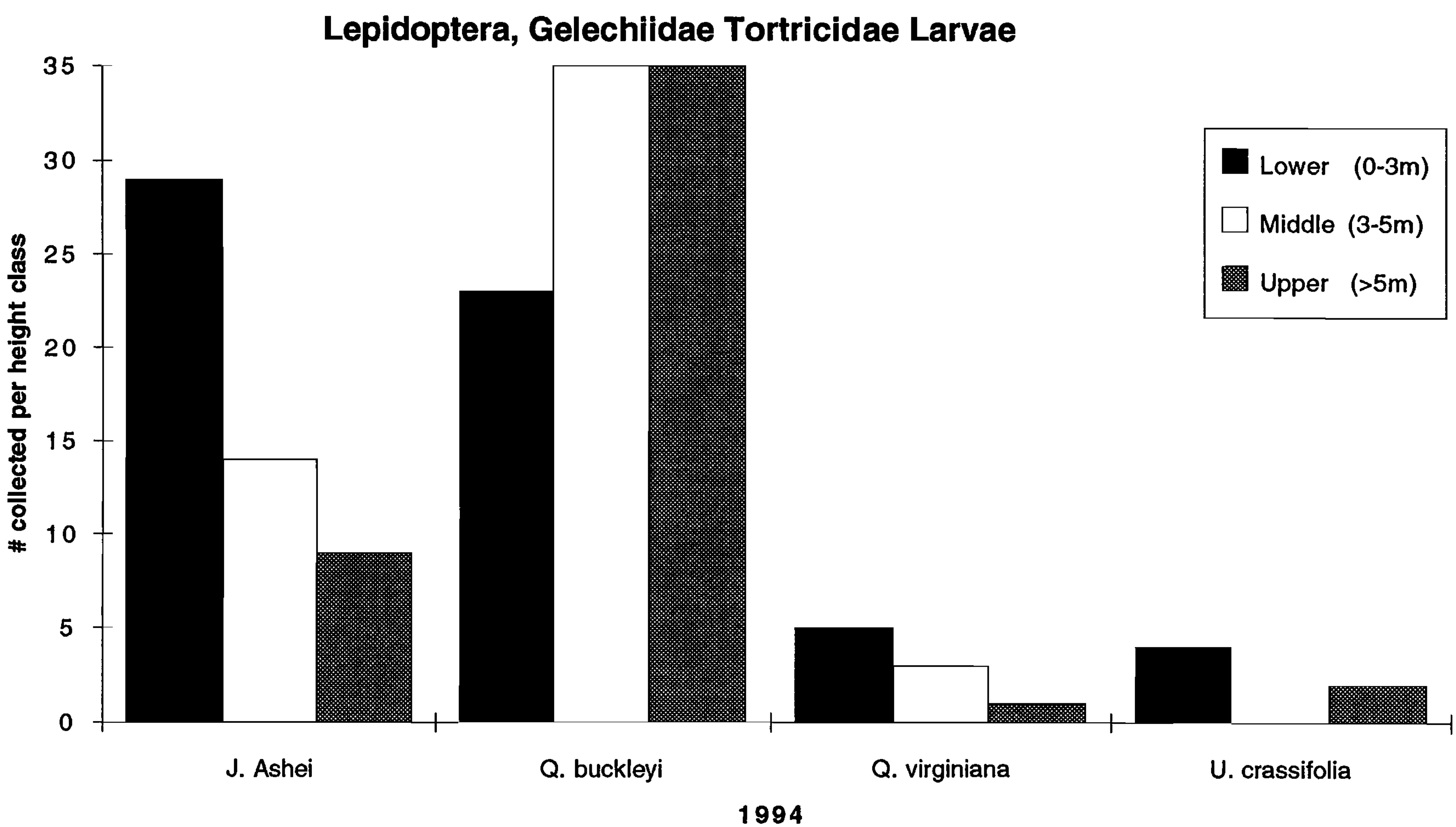
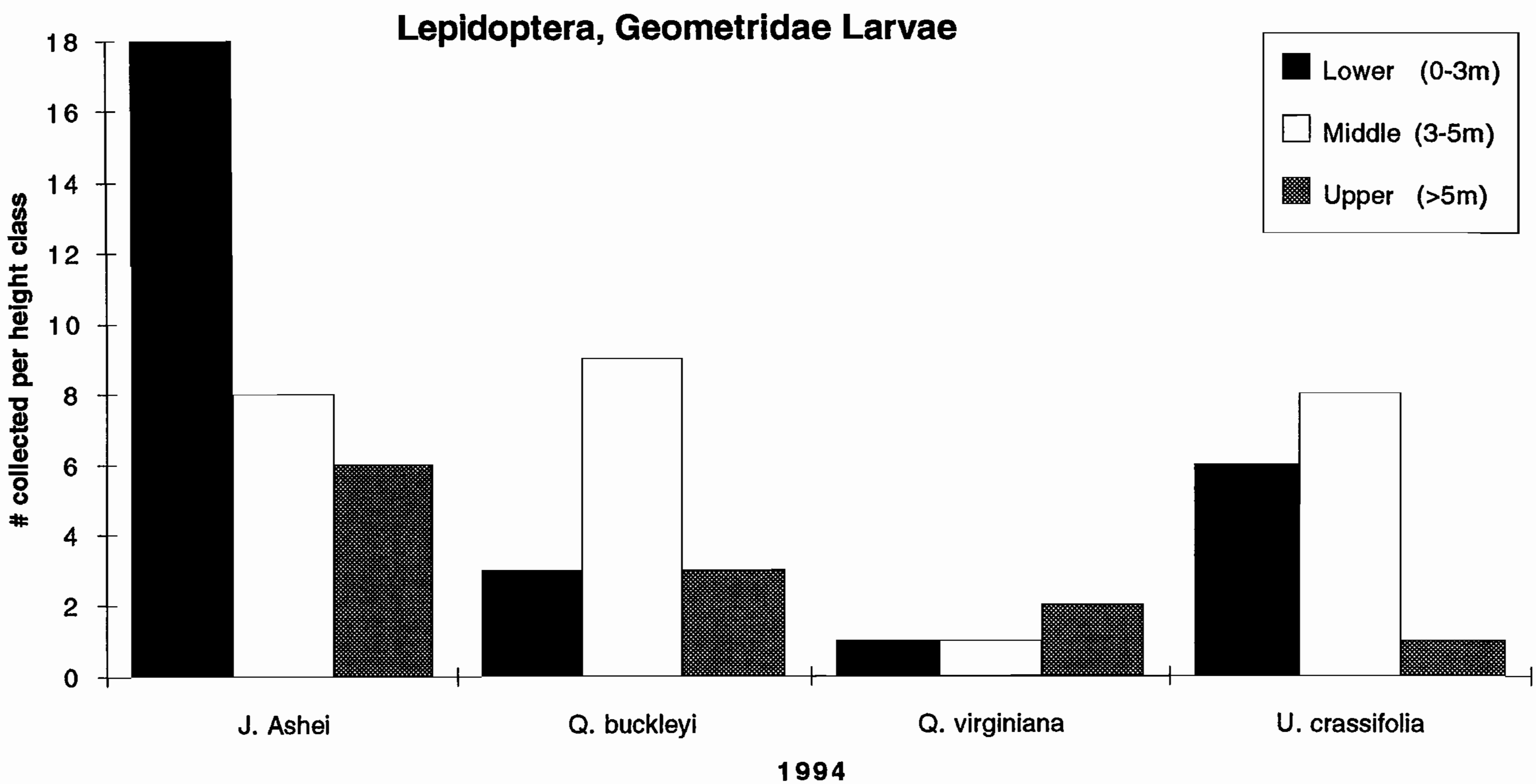

Lepidoptera, Gelechiidae Tortricidae Larvae
collected per height class
35
30
25
20
15
10
5
0
Lower (0-3m)
Middle (3-5m)
Upper (>5m)
J. Ashei
Q. buckleyi
Q. virginiana
U. crassifolia
1994

Figure 14



Lepidoptera, Geometridae Larvae
18
16
14
12
10
8
6
4
2
0
collected per height class
Lower (0-3m)
Middle (3-5m)
Upper (>5m)
J. Ashei
Q. buckleyi
Q. virginiana
U. crassifolia
1994

Figure 15

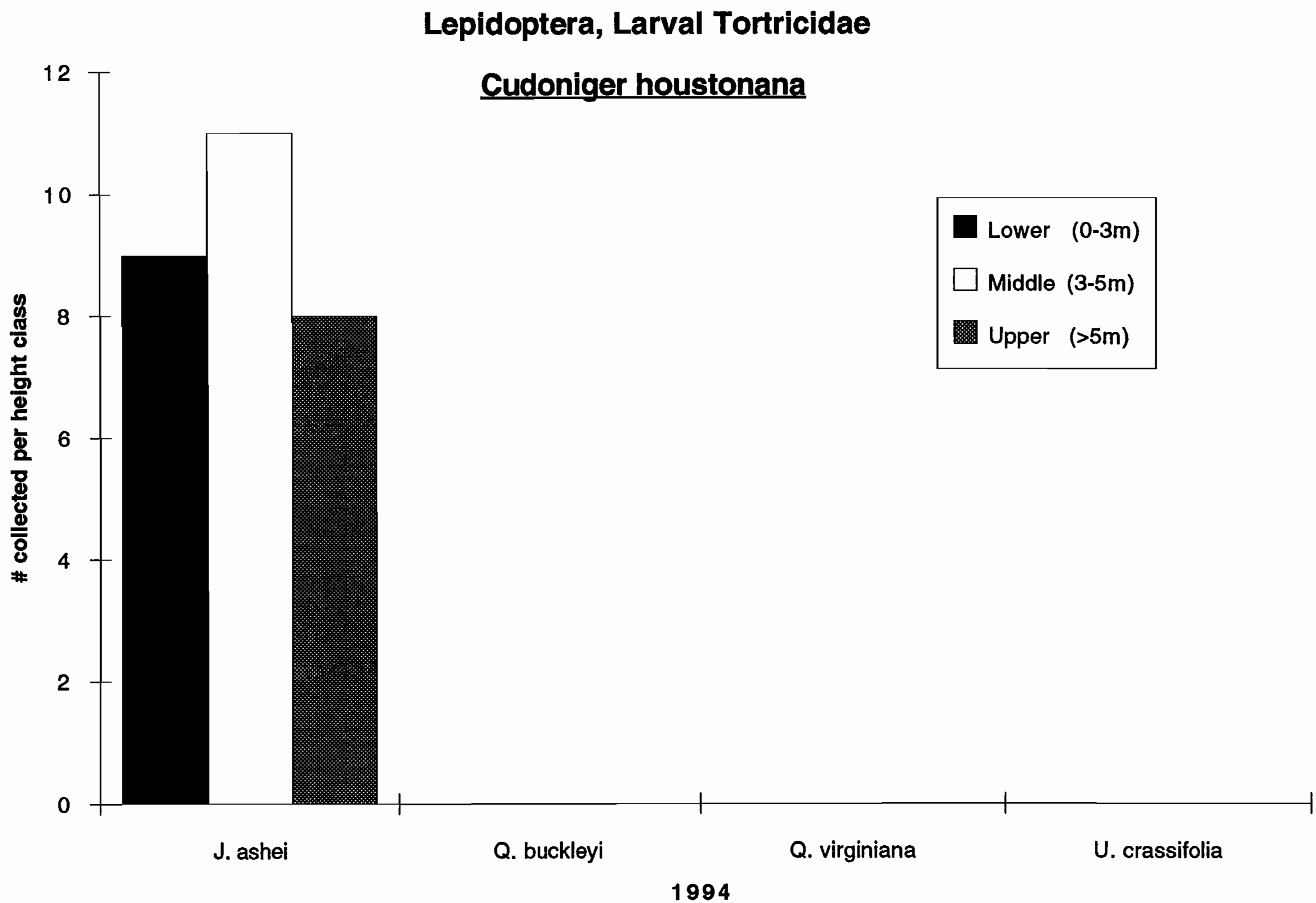

Lepidoptera, Larval Tortricidae
Cudoniger houstonana
collected per height class
12
10
8
6
4
2
0
Lower (0-3m)
Middle (3-5m)
Upper (>5m)
J. ashei
Q. buckleyi
Q. virginiana
U. crassifolia
1994

Figure 16

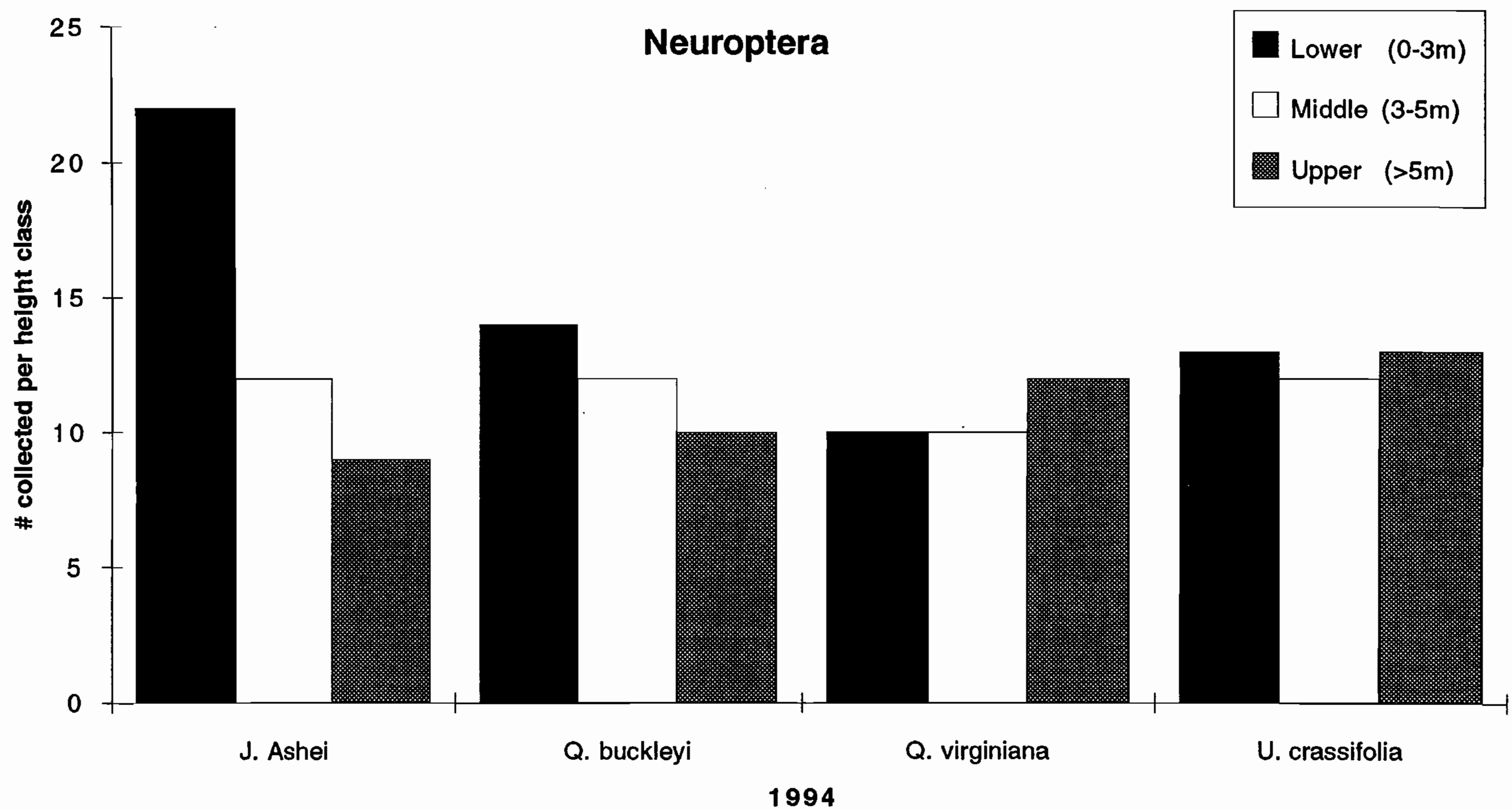

Neuroptera
Lower (0-3m)
Middle (3-5m)
Upper (>5m)
collected per height class
25
20
15
10
5
0
J. Ashei
Q. buckleyi
Q. virginiana
U. crassifolia
1994

Figure 17

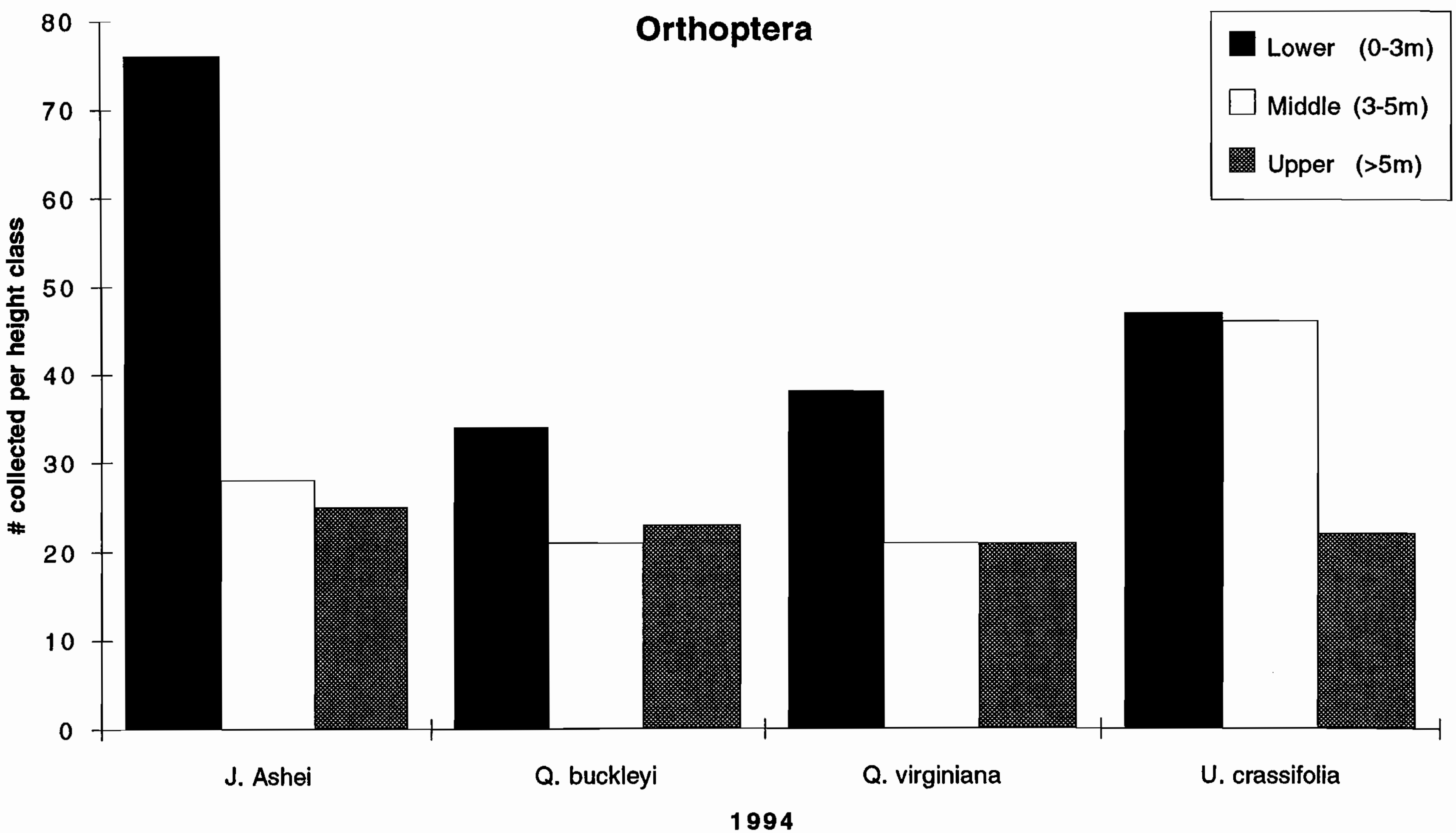

Orthoptera
Lower (0-3m)
Middle (3-5m)
Upper (>5m)
collected per height class
0
10
20
30
40
50
60
70
80
J. Ashei
Q. buckleyi
Q. virginiana
U. crassifolia
1994

Figure 18

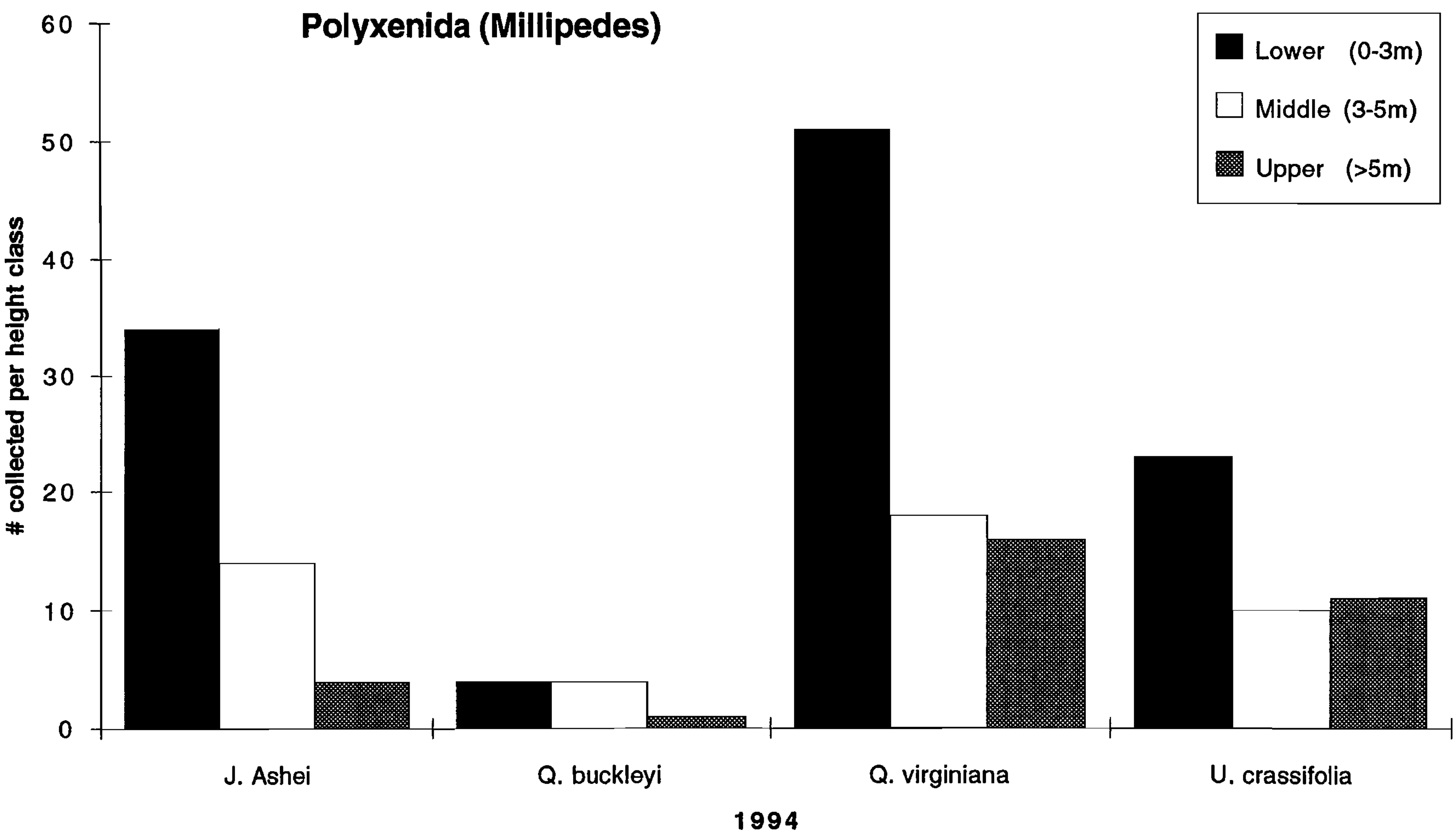
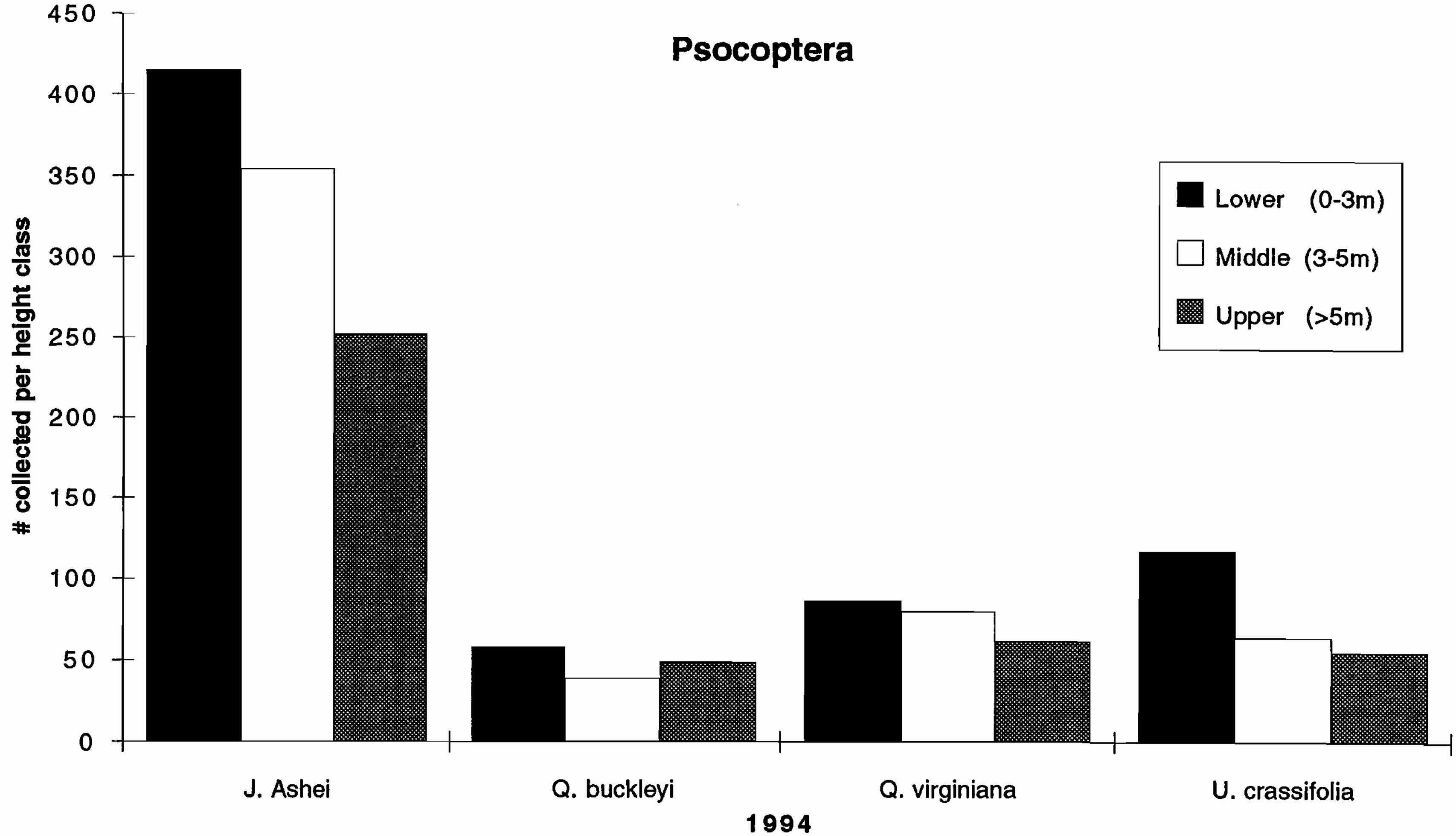
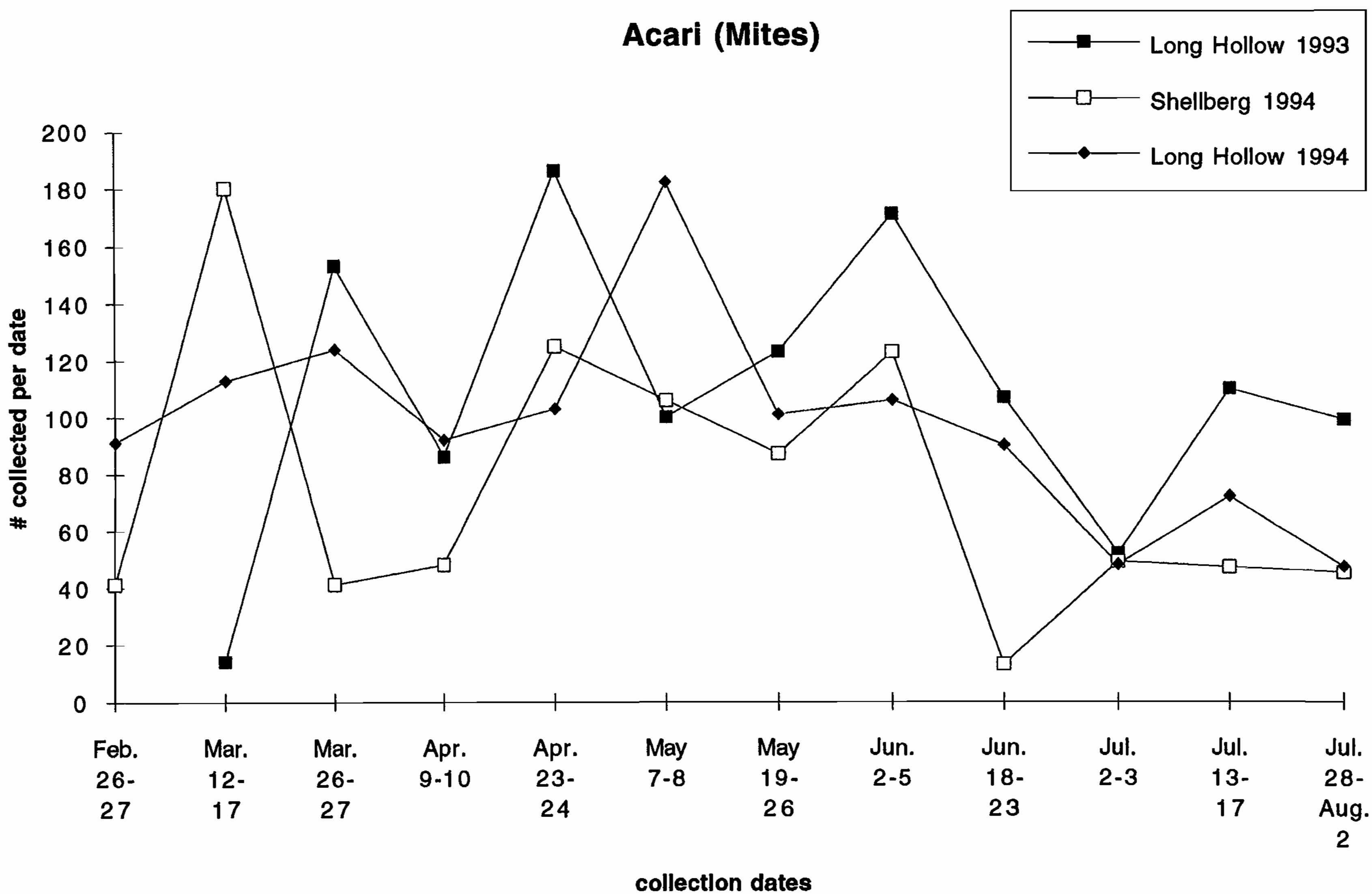

Polyxenida (Millipedes)
Lower (0-3m)
Middle (3-5m)
Upper (>5m)
collected per height class
60
50
40
30
20
10
0
J. Ashei
Q. buckleyi
Q. virginiana
U. crassifolia
1994

Figure 19



Psocoptera
450
400
350
300
250
200
150
100
50
0
collected per height class
Lower (0-3m)
Middle (3-5m)
Upper (>5m)
J. Ashei
Q. buckleyi
Q. virginiana
U. crassifolia
1994

Figure 20



Acari (Mites)
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
200
180
160
140
120
100
80
60
40
20
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 21

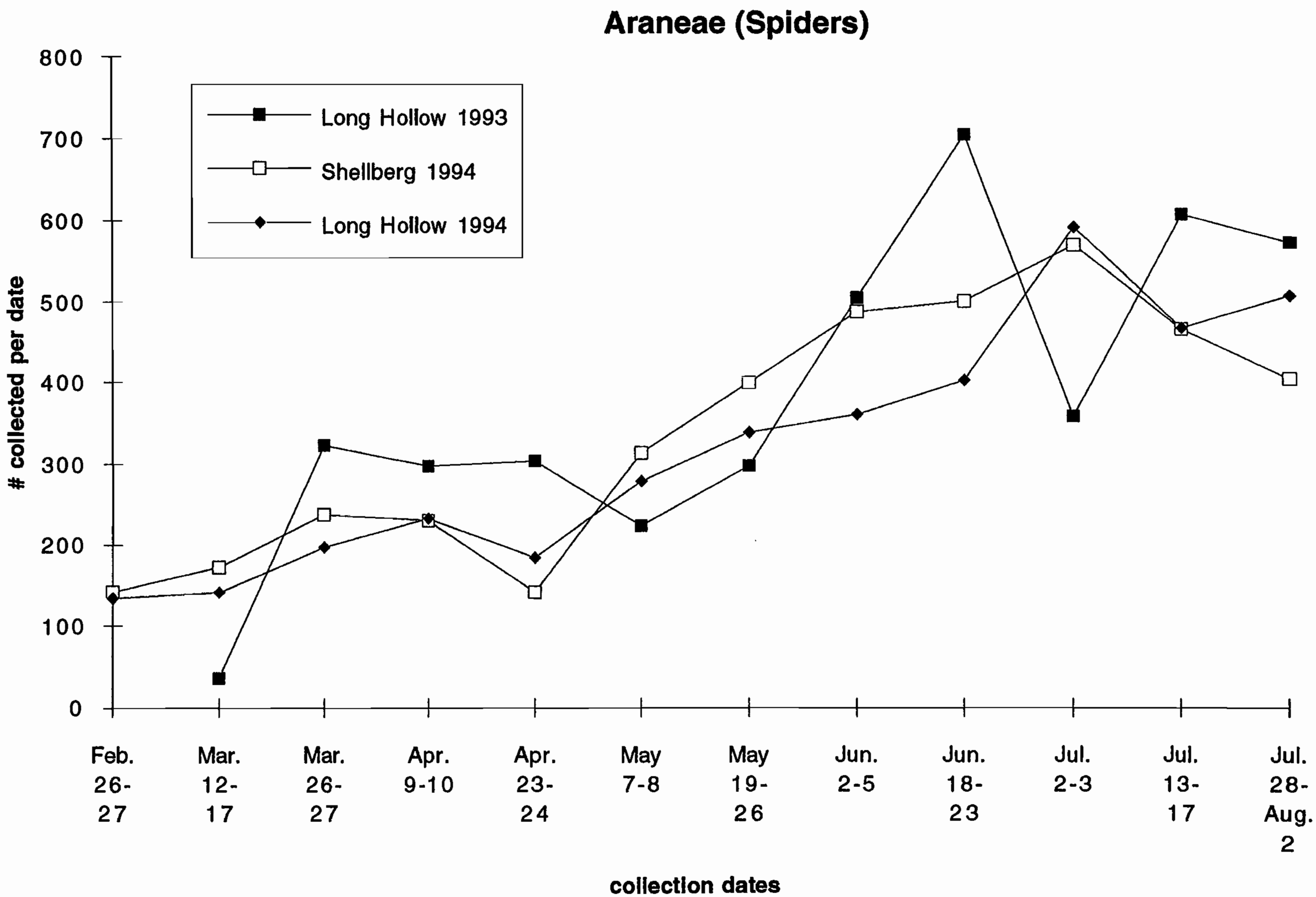

Araneae (Spiders)
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
800
700
600
500
400
300
200
100
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 22

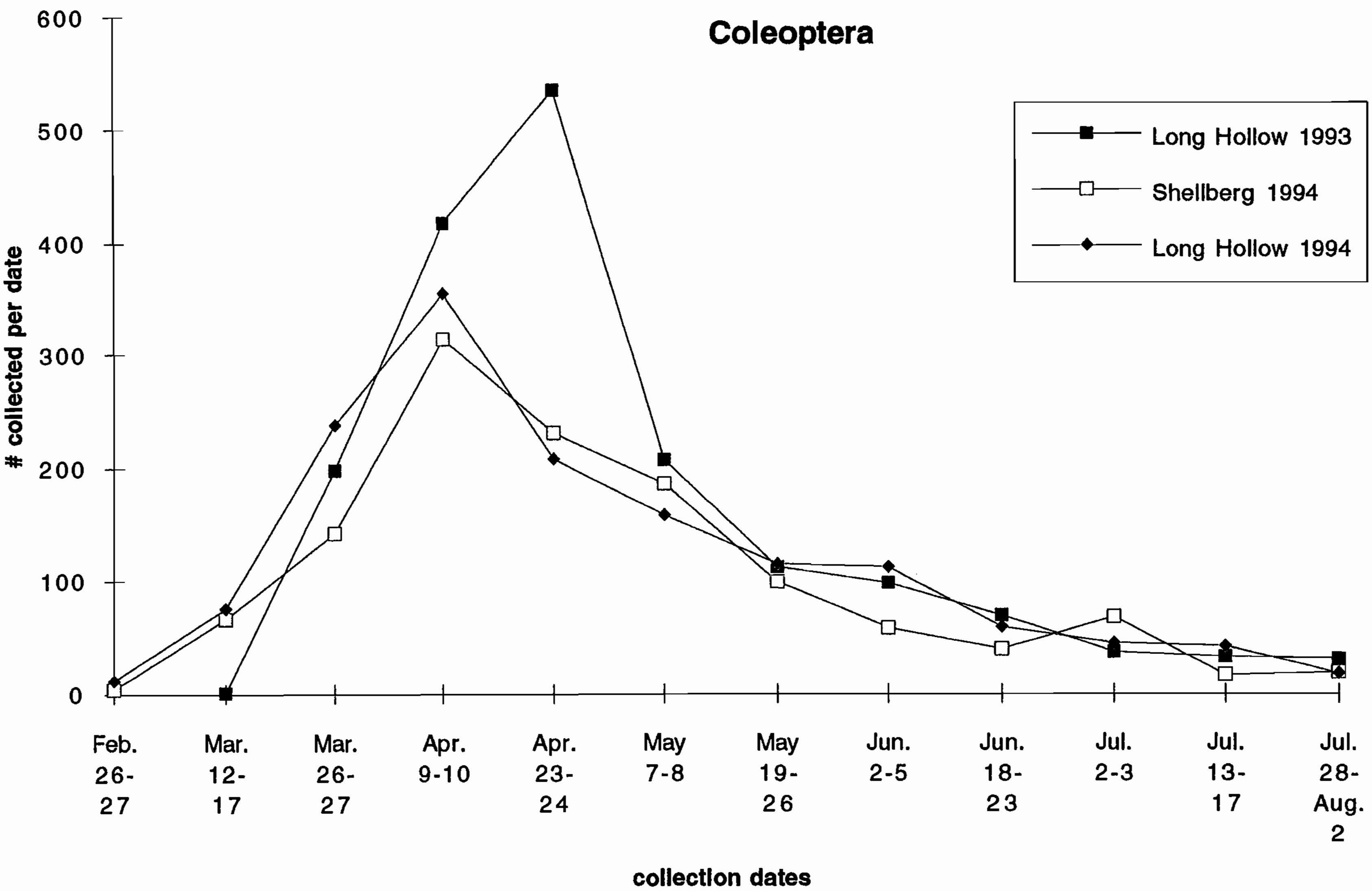

Coleoptera
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
600
500
400
300
200
100
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 23

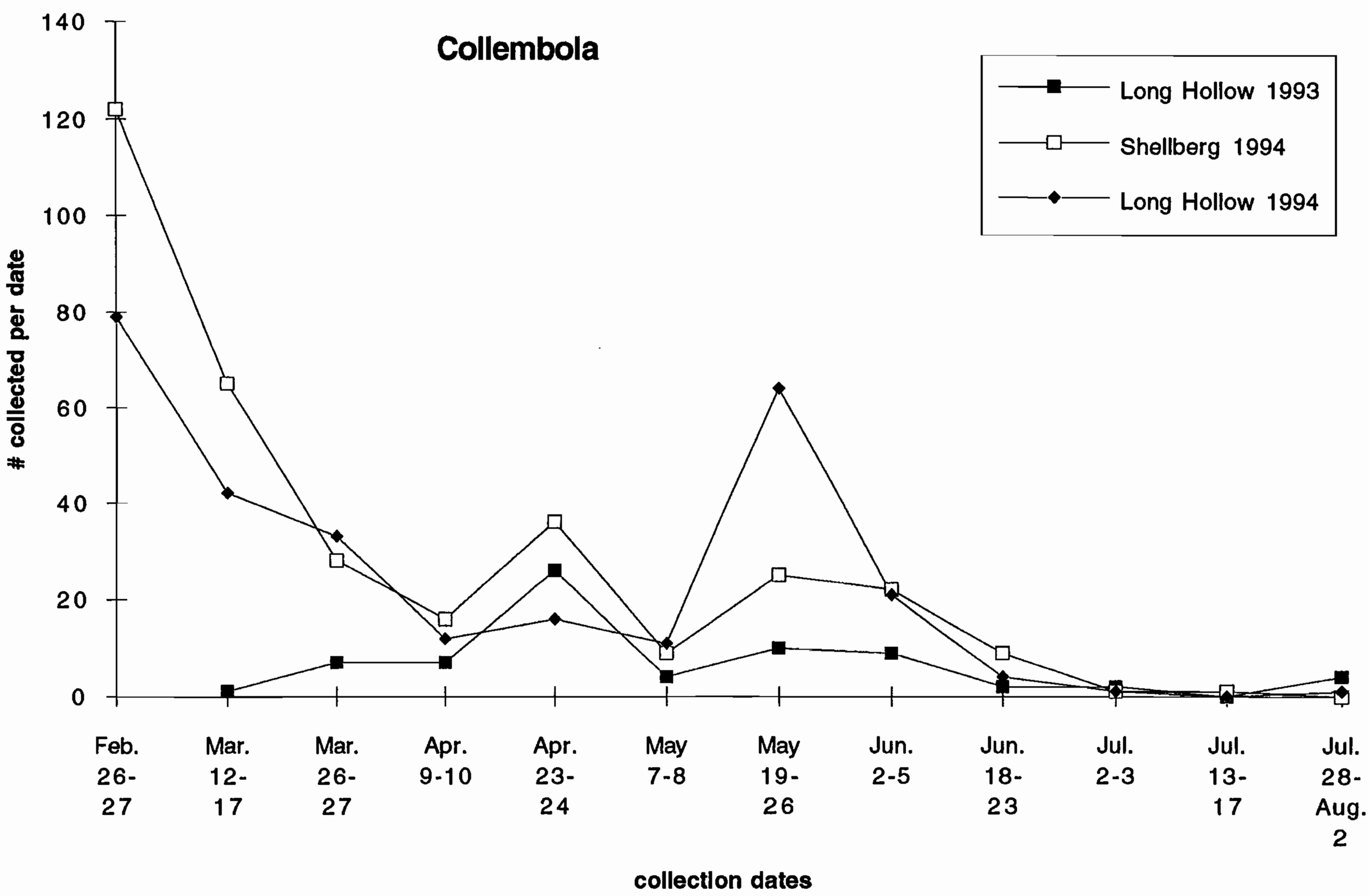

Collembola
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
140
120
100
80
60
40
20
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 24

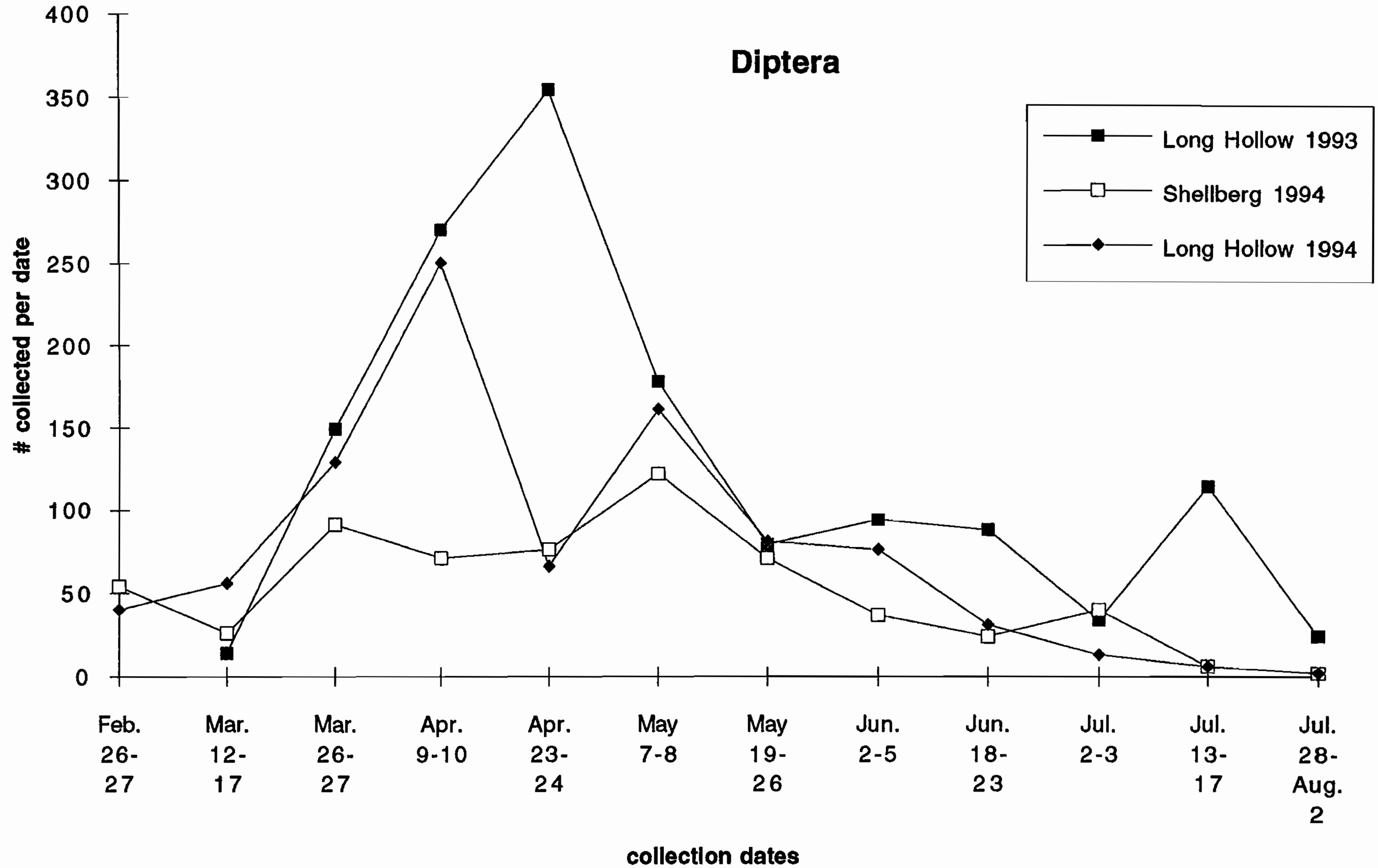
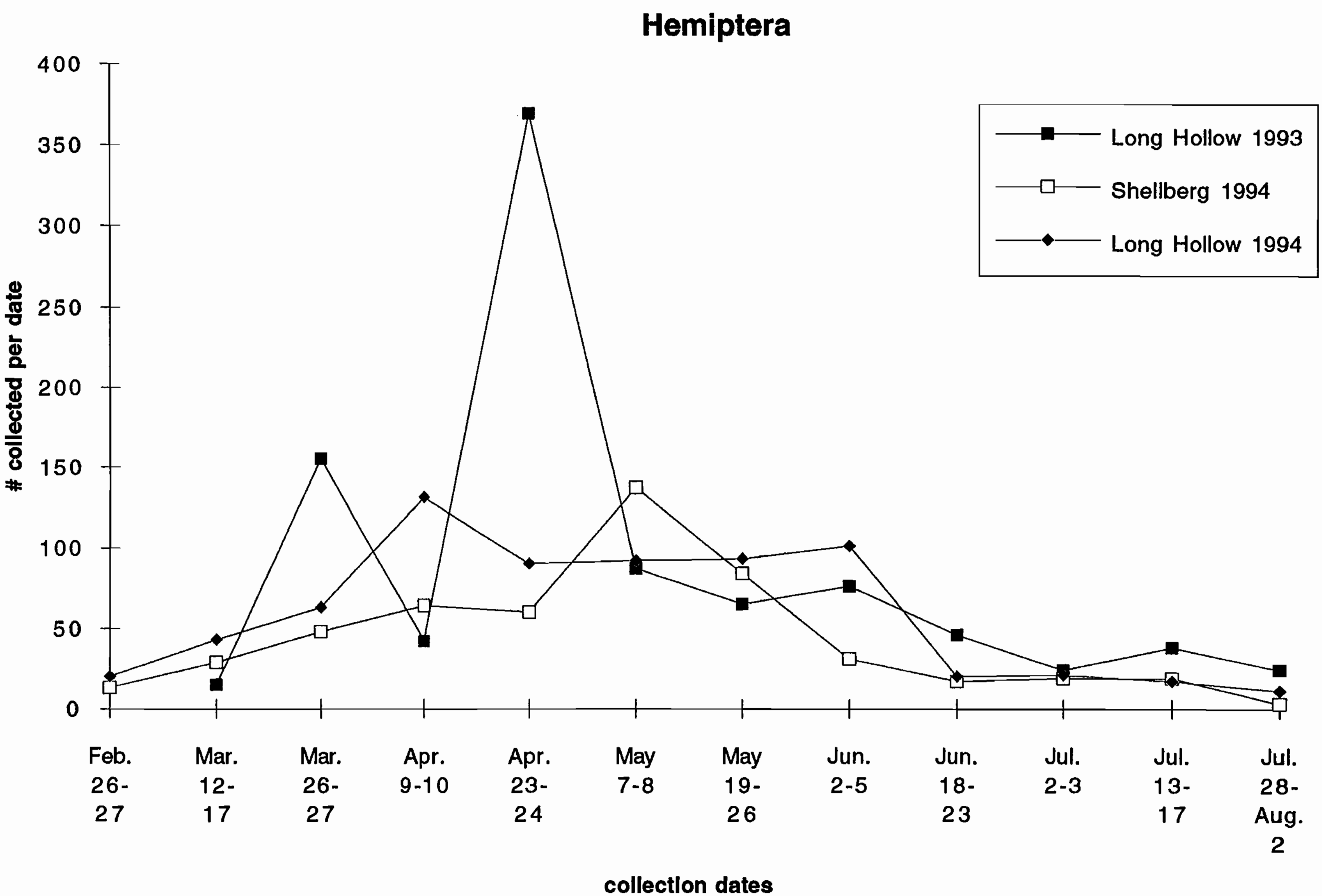

Diptera
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
400
350
300
250
200
150
100
50
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 25



Hemiptera
400
350
300
250
200
150
100
50
0
collected per date
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 26

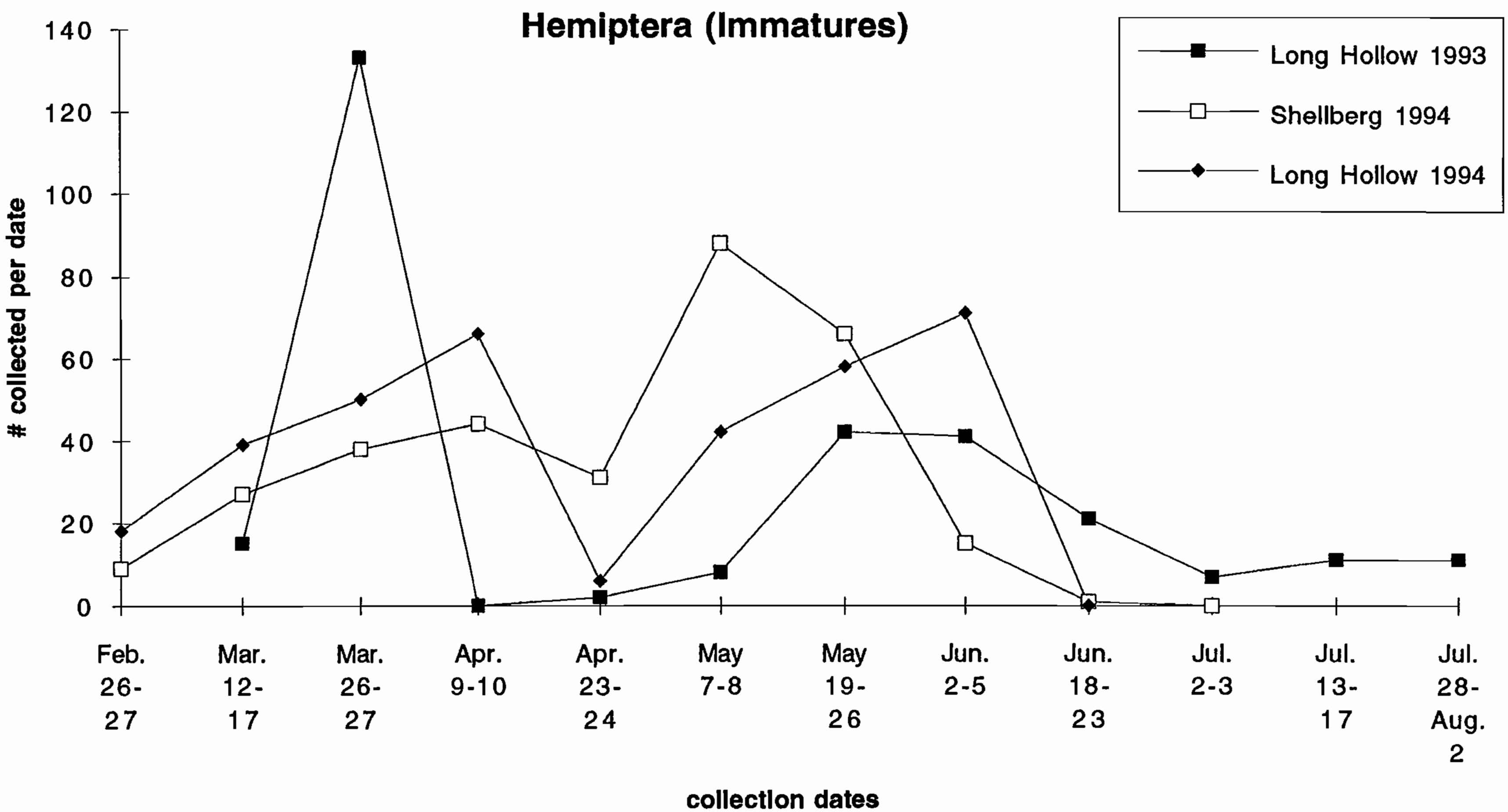

Hemiptera (Immatures)
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
140
120
100
80
60
40
20
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 27

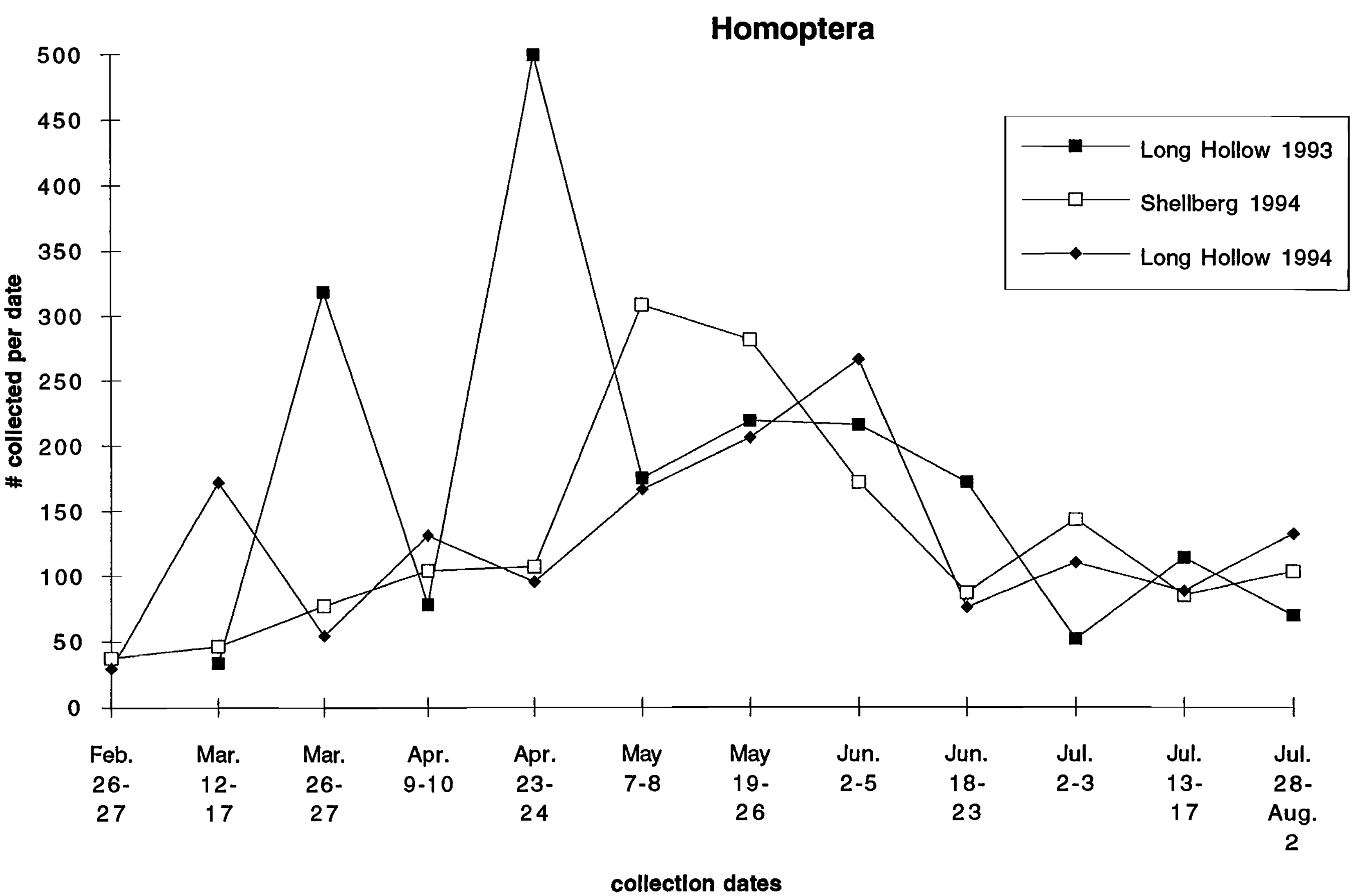
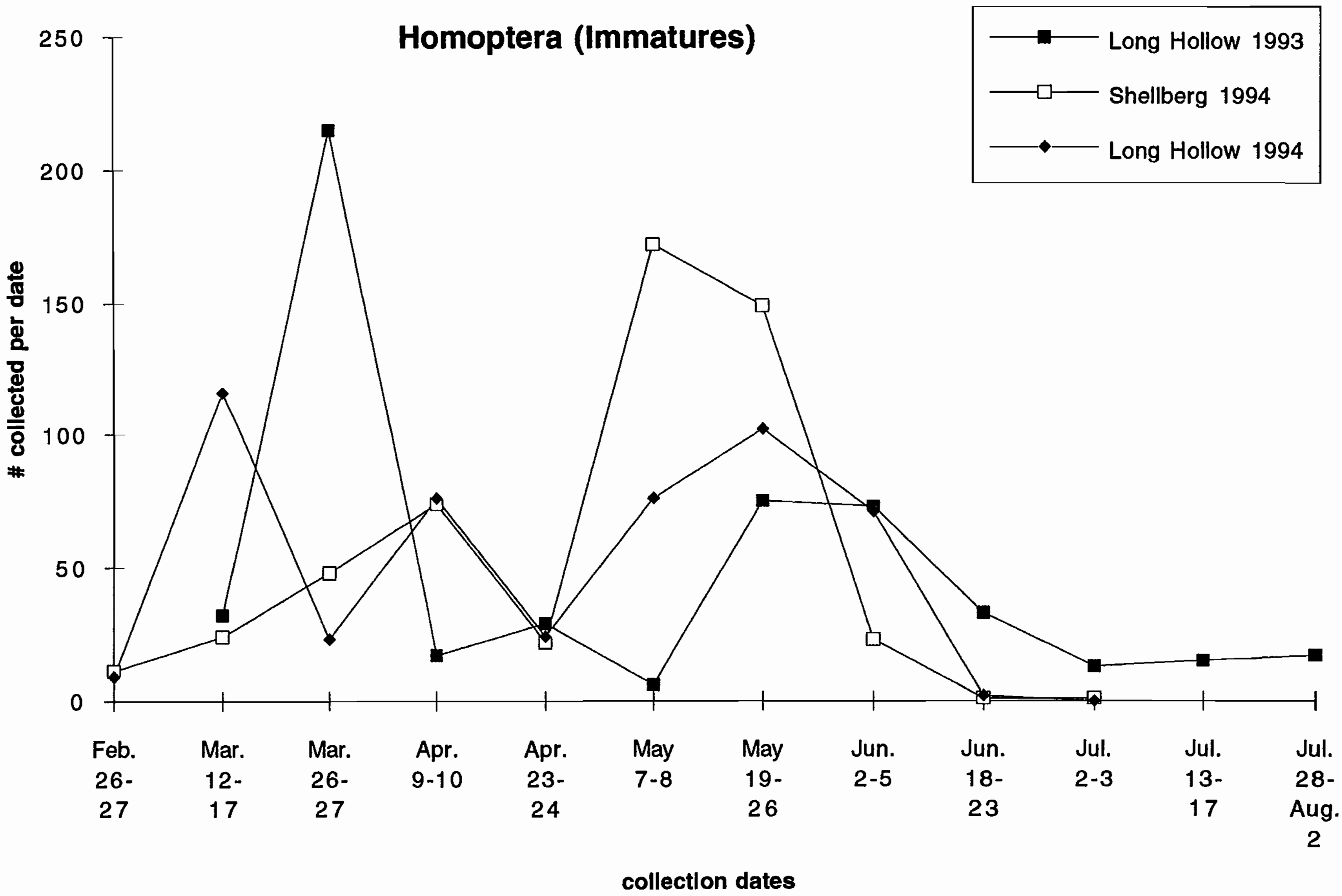
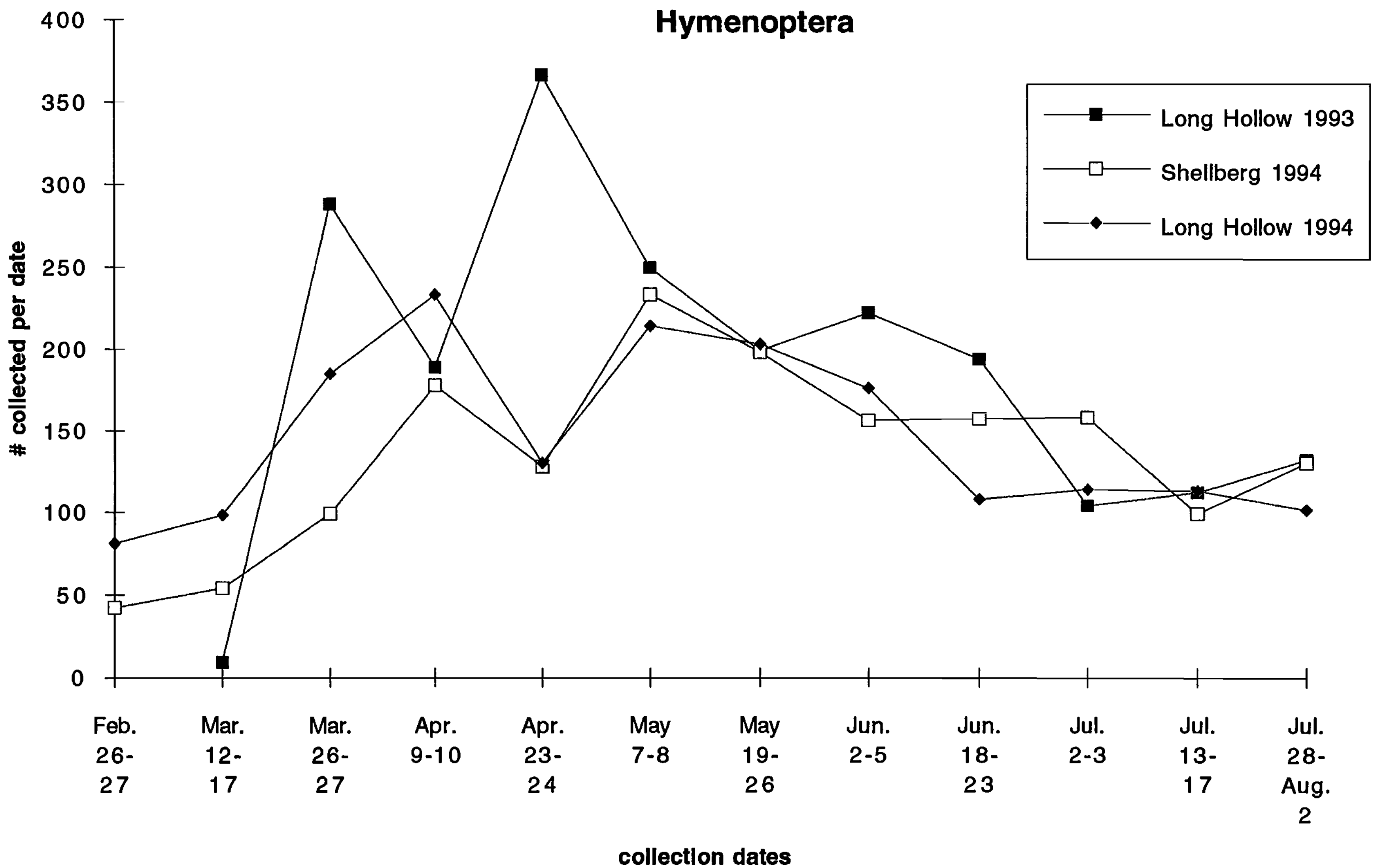

Homoptera
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
500
450
400
350
300
250
200
150
100
50
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 28



Homoptera (Immatures)
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
250
200
150
100
50
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 29



Hymenoptera
collected per date
400
350
300
250
200
150
100
50
0
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 30

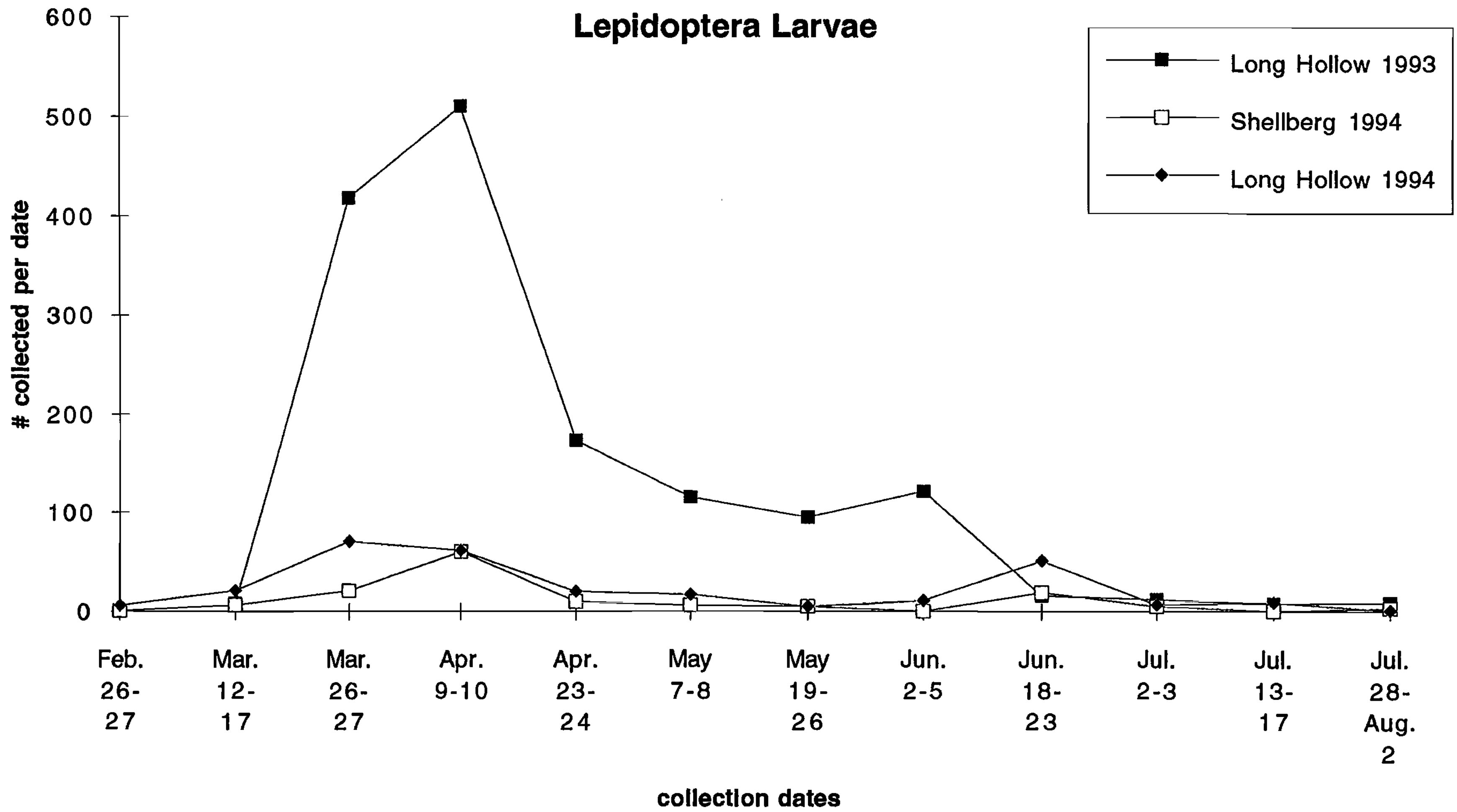

Lepidoptera Larvae
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
600
500
400
300
200
100
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 31

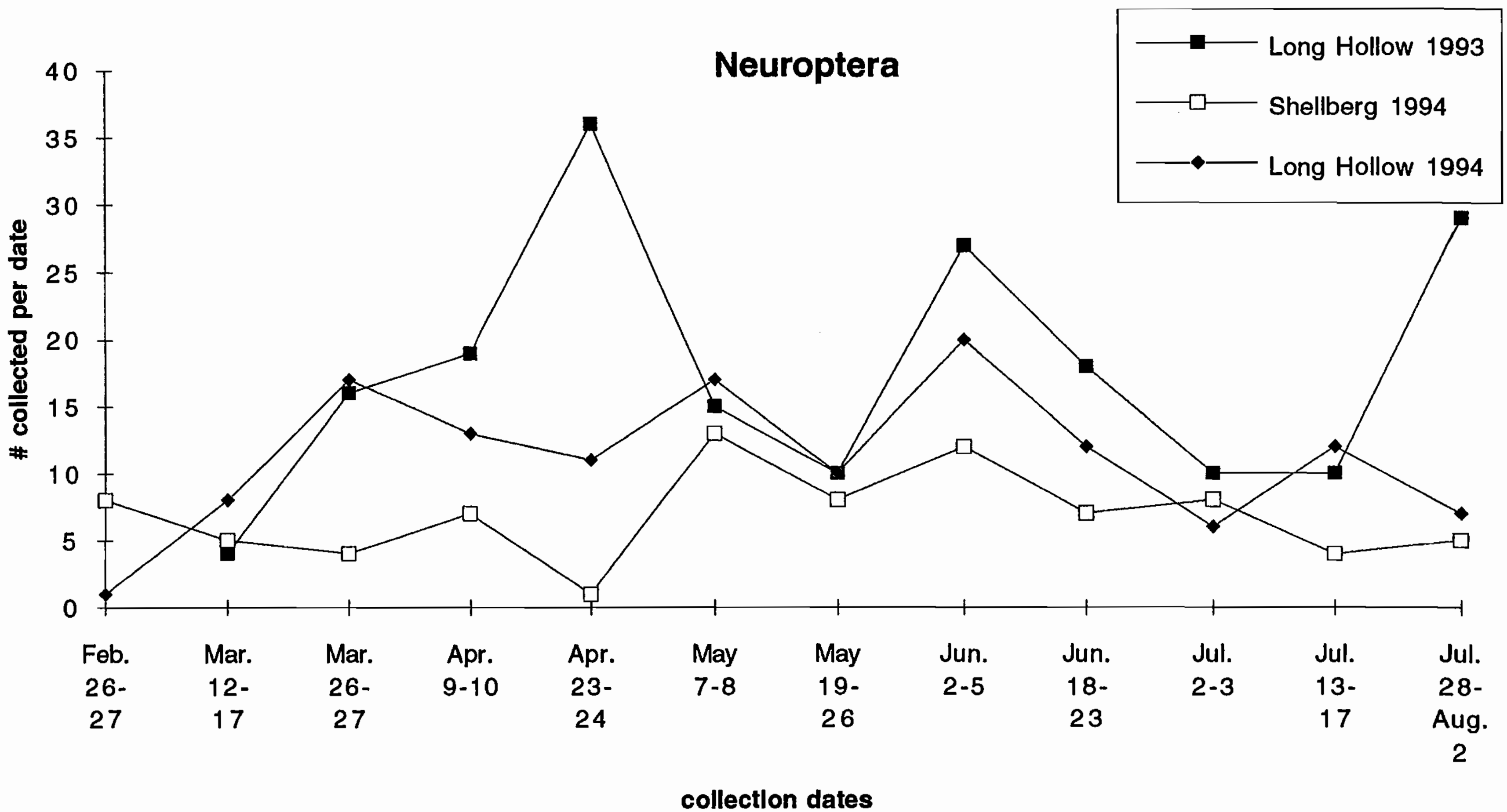

Neuroptera
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
0
5
10
15
20
25
30
35
40
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 32

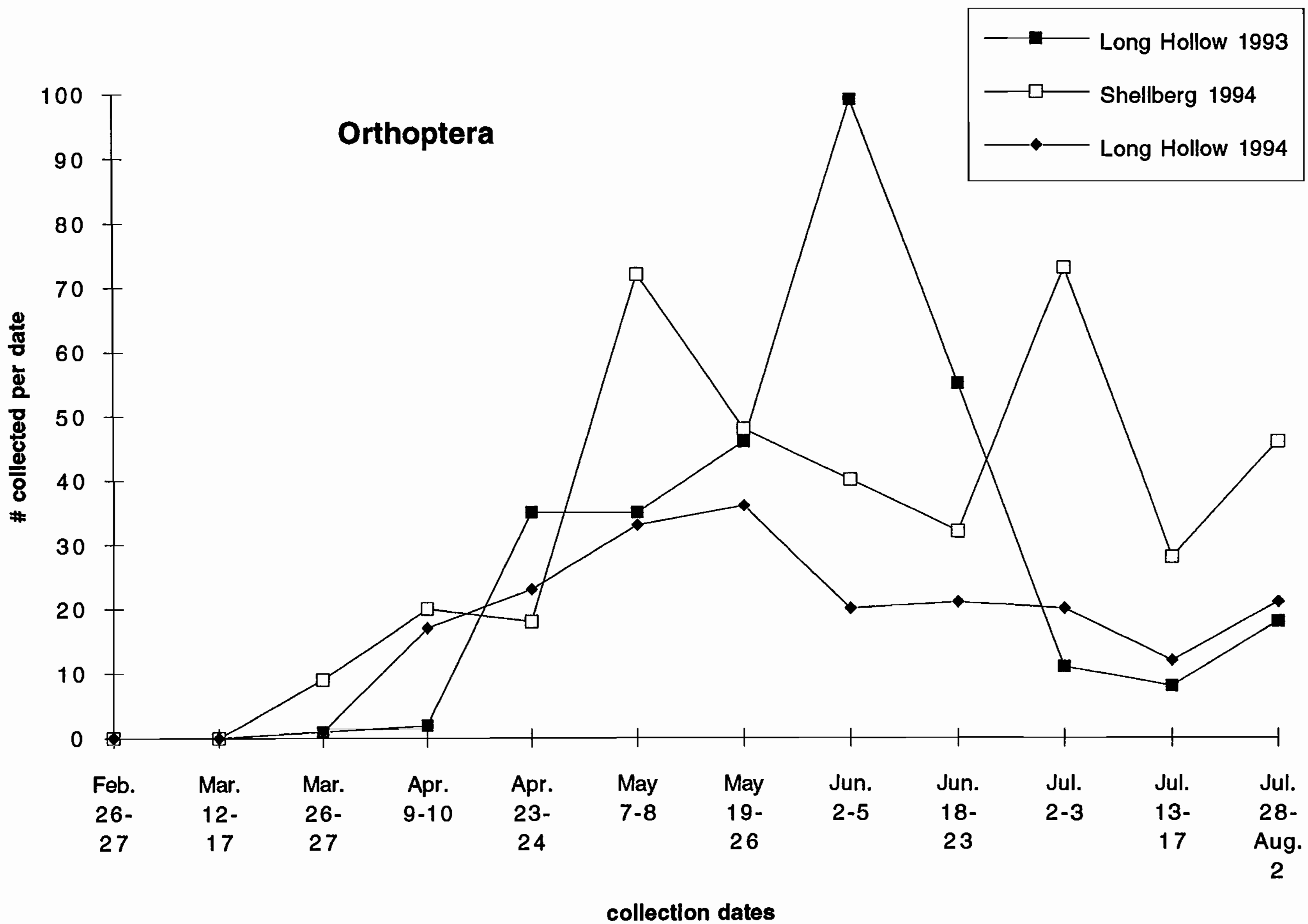
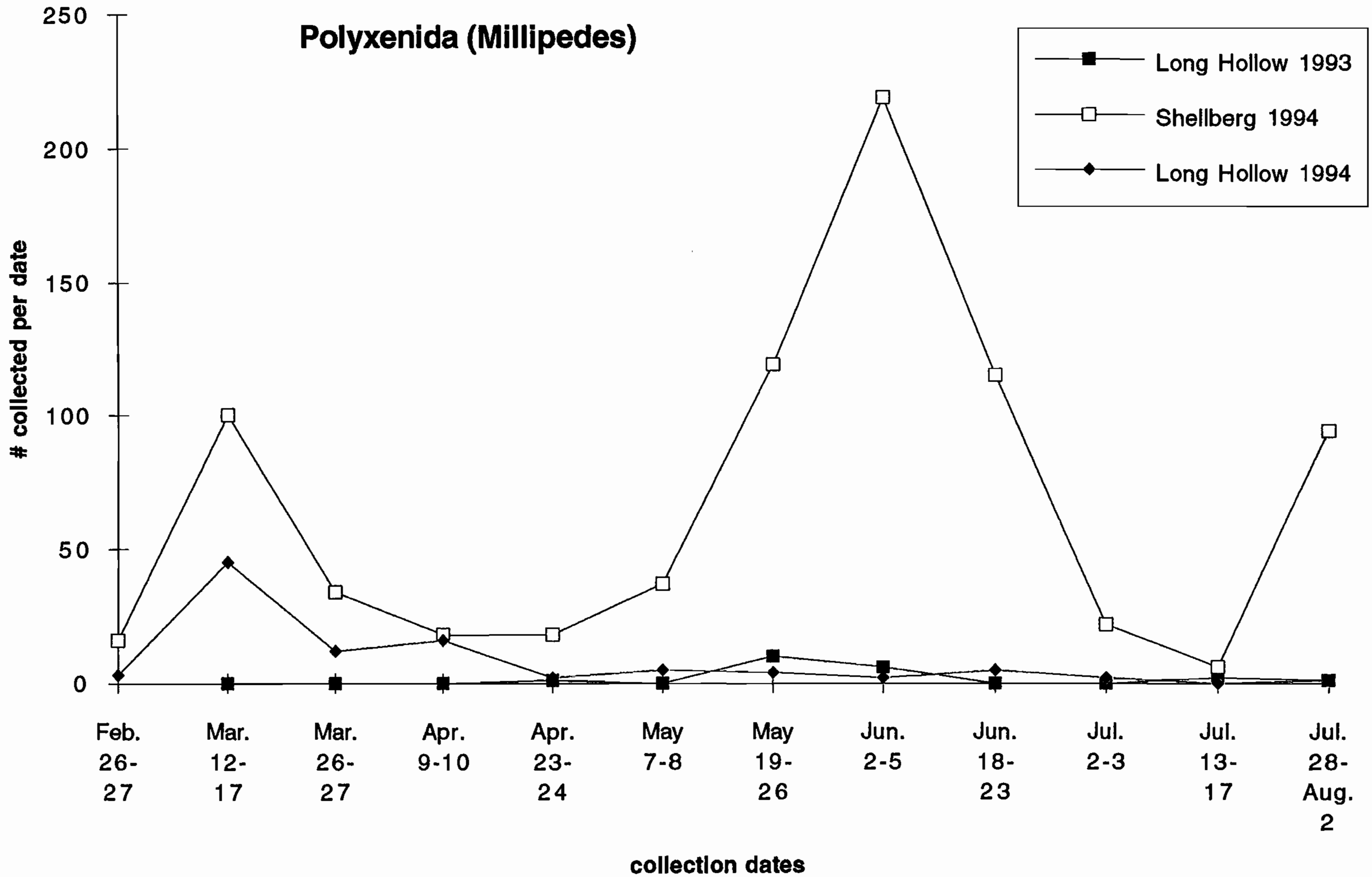

Orthoptera
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
100
90
80
70
60
50
40
30
20
10
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 33



Polyxenida (Millipedes)
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
250
200
150
100
50
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 34

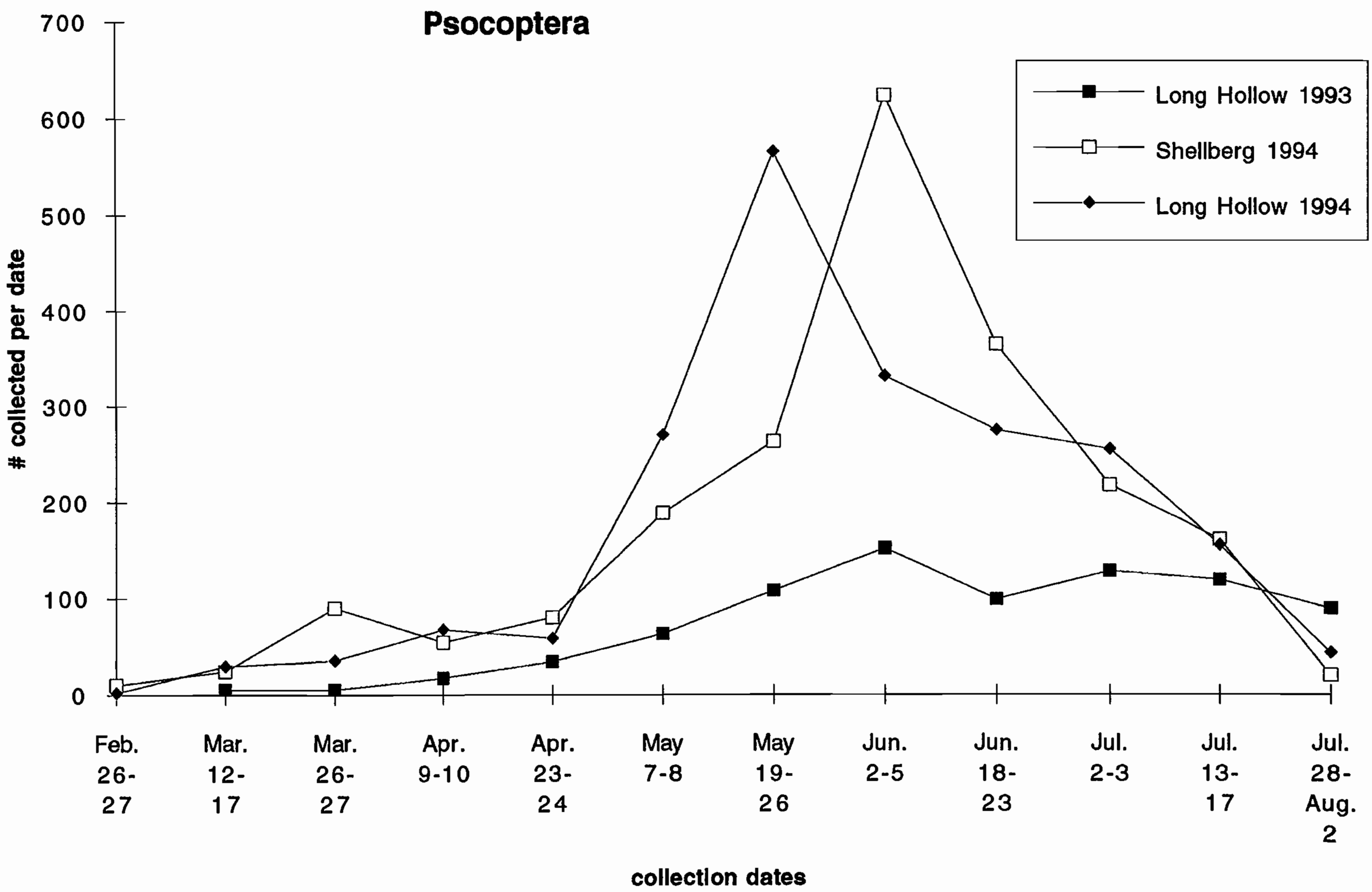

Psocoptera
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
700
600
500
400
300
200
100
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 35

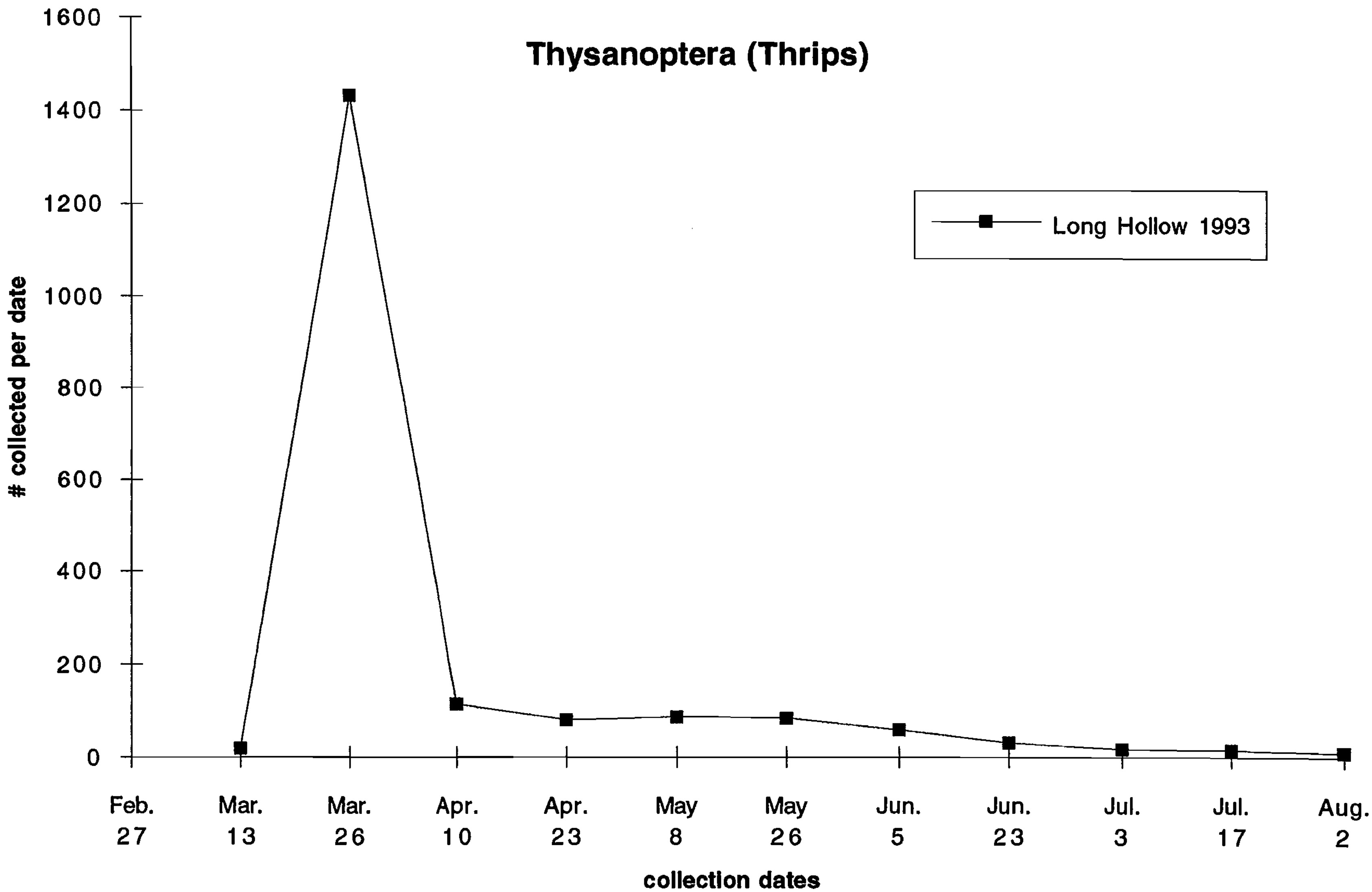

Thysanoptera (Thrips)
Long Hollow 1993
collected per date
1600
1400
1200
1000
800
600
400
200
0
Feb. 27
Mar. 13
Mar. 26
Apr. 10
Apr. 23
May 8
May 26
Jun. 5
Jun. 23
Jul. 3
Jul. 17
Aug. 2
collection dates

Figure 36

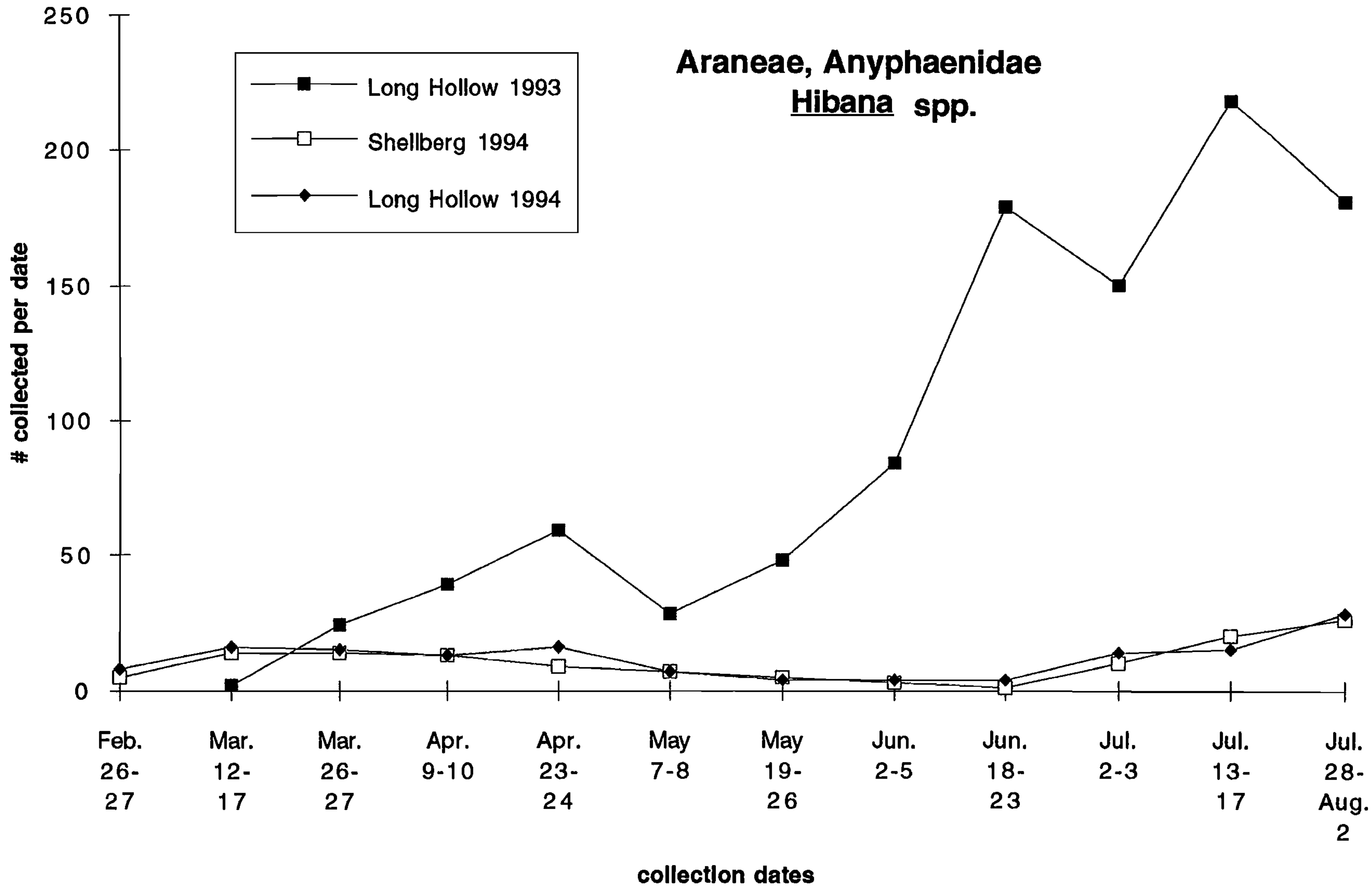
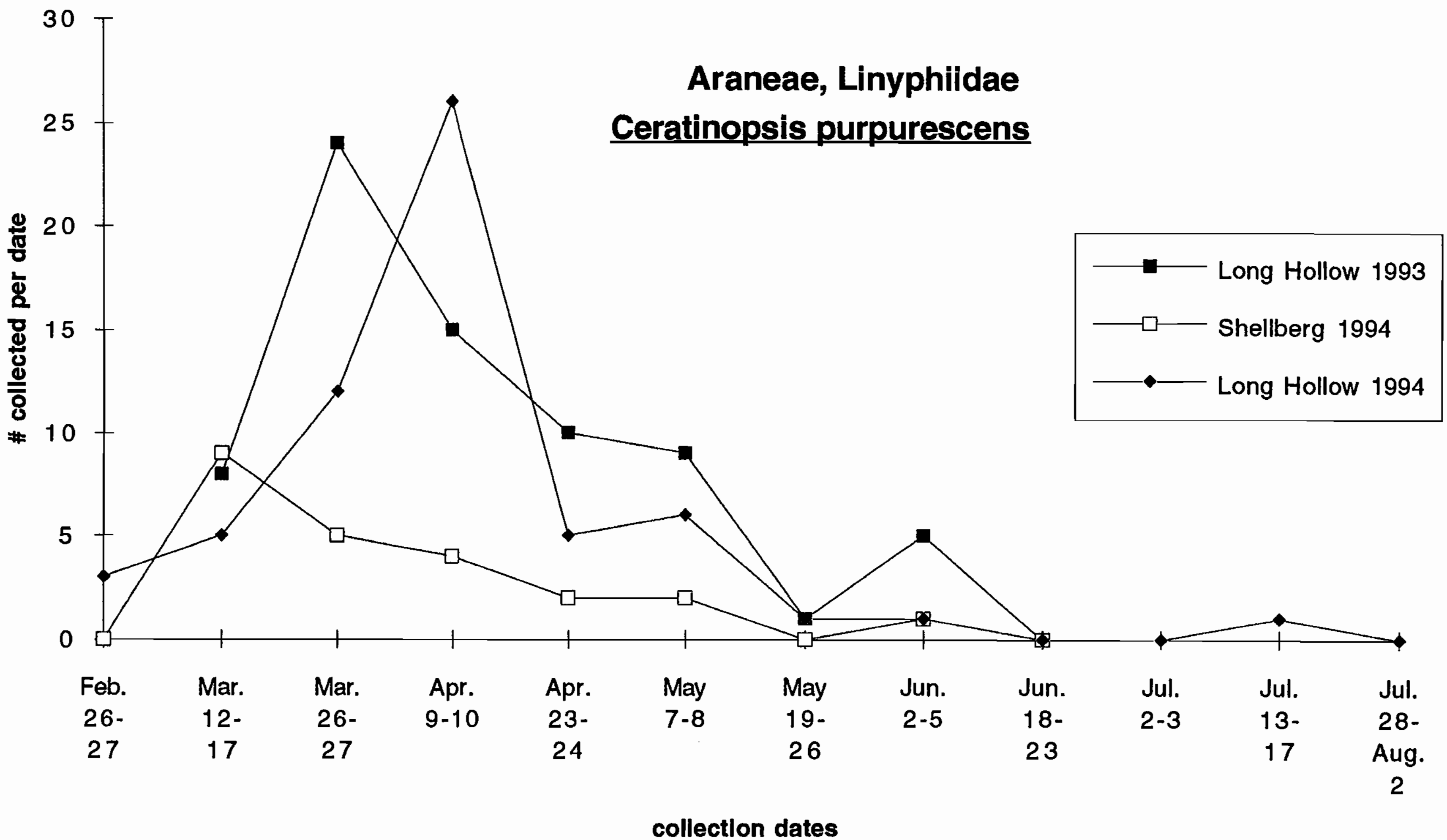

Araneae, Anyphaenidae
Hibana spp.
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
250
200
150
100
50
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 37



Araneae, Linyphiidae
Ceratinopsis purpurescens
collected per date
30
25
20
15
10
5
0
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 38

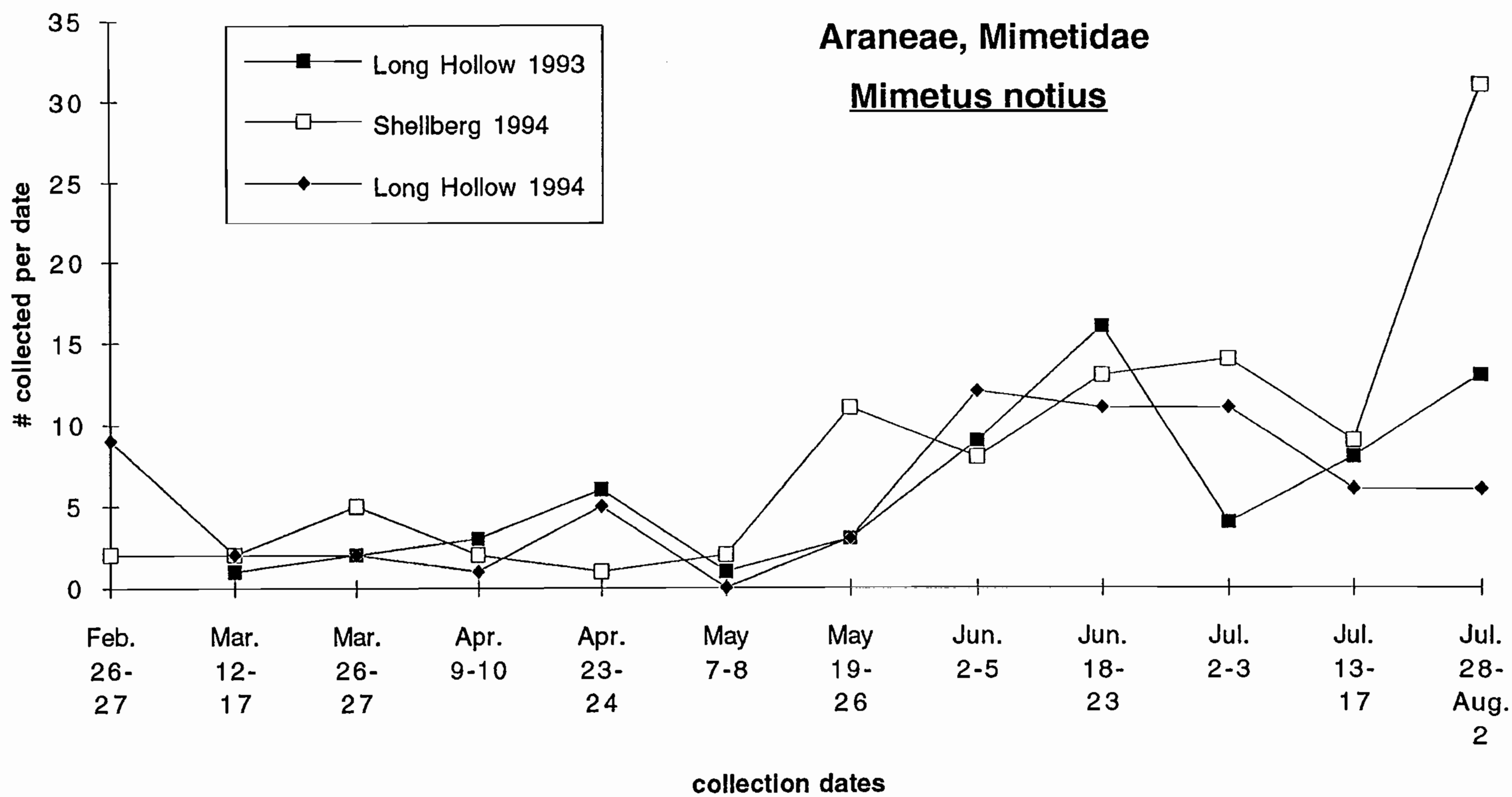

Araneae, Mimetidae
Mimetus notius
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
35
30
25
20
15
10
5
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 39

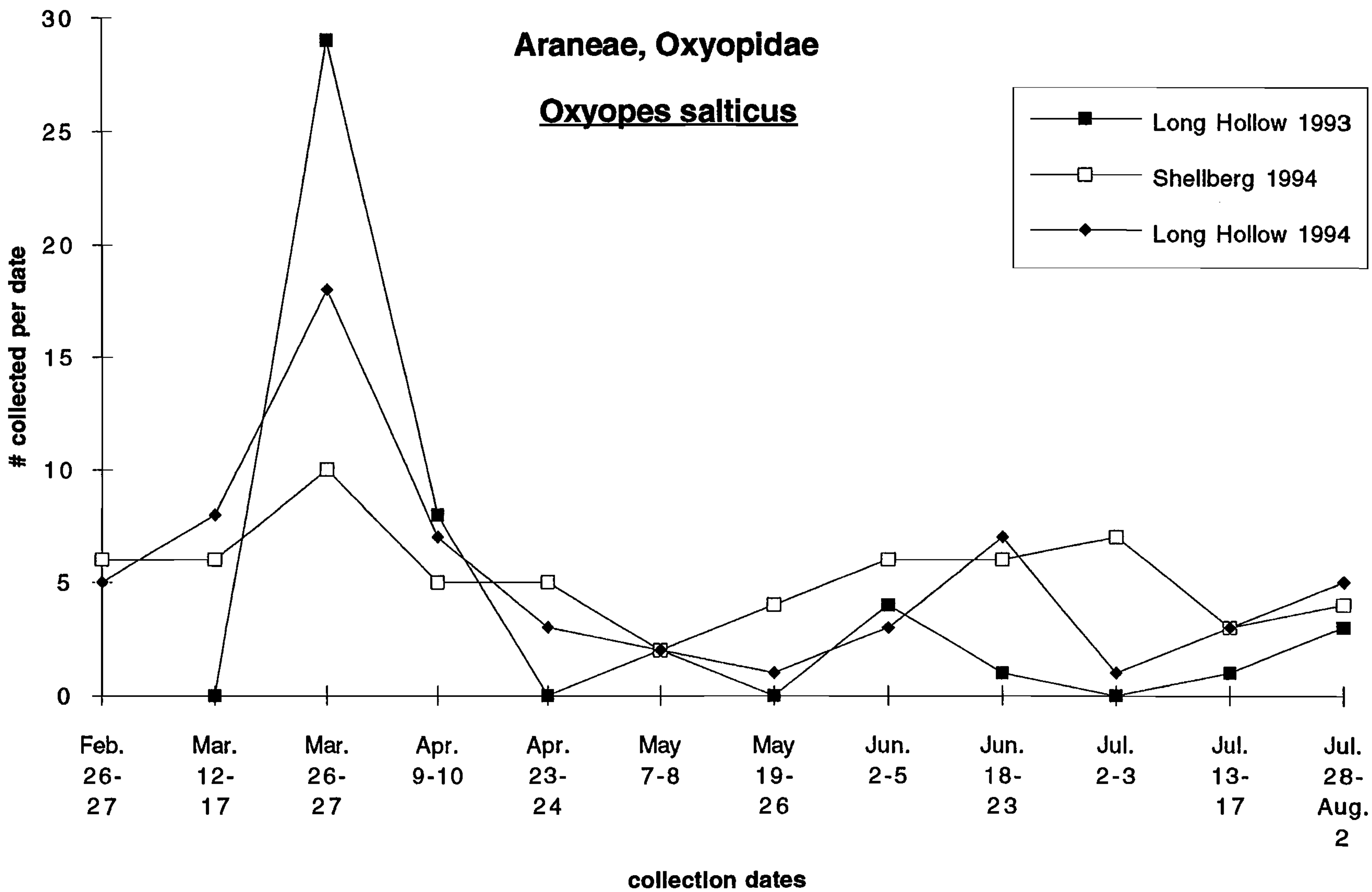

Araneae, Oxyopidae
Oxyopes salticus
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
30
25
20
15
10
5
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 40

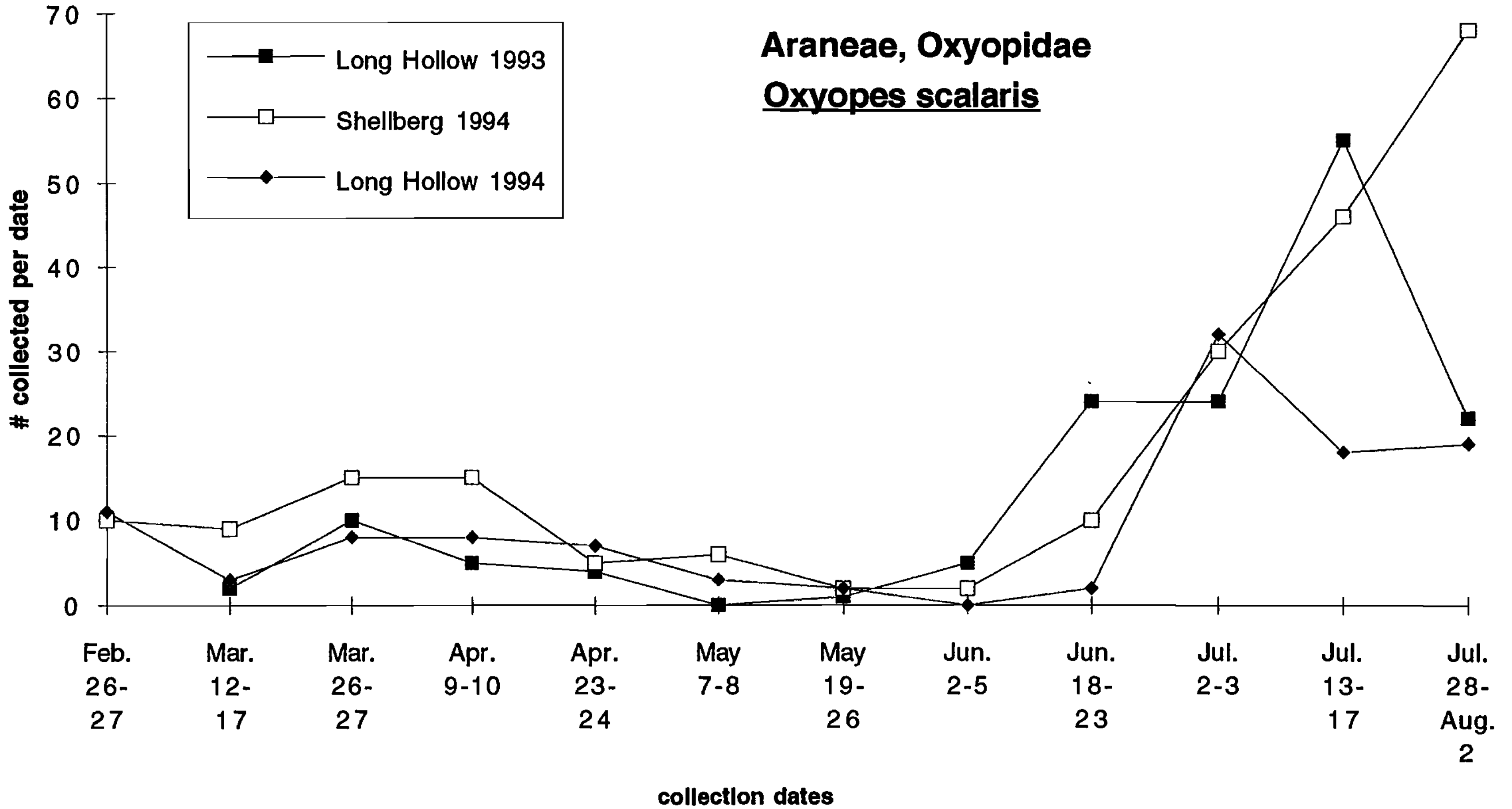
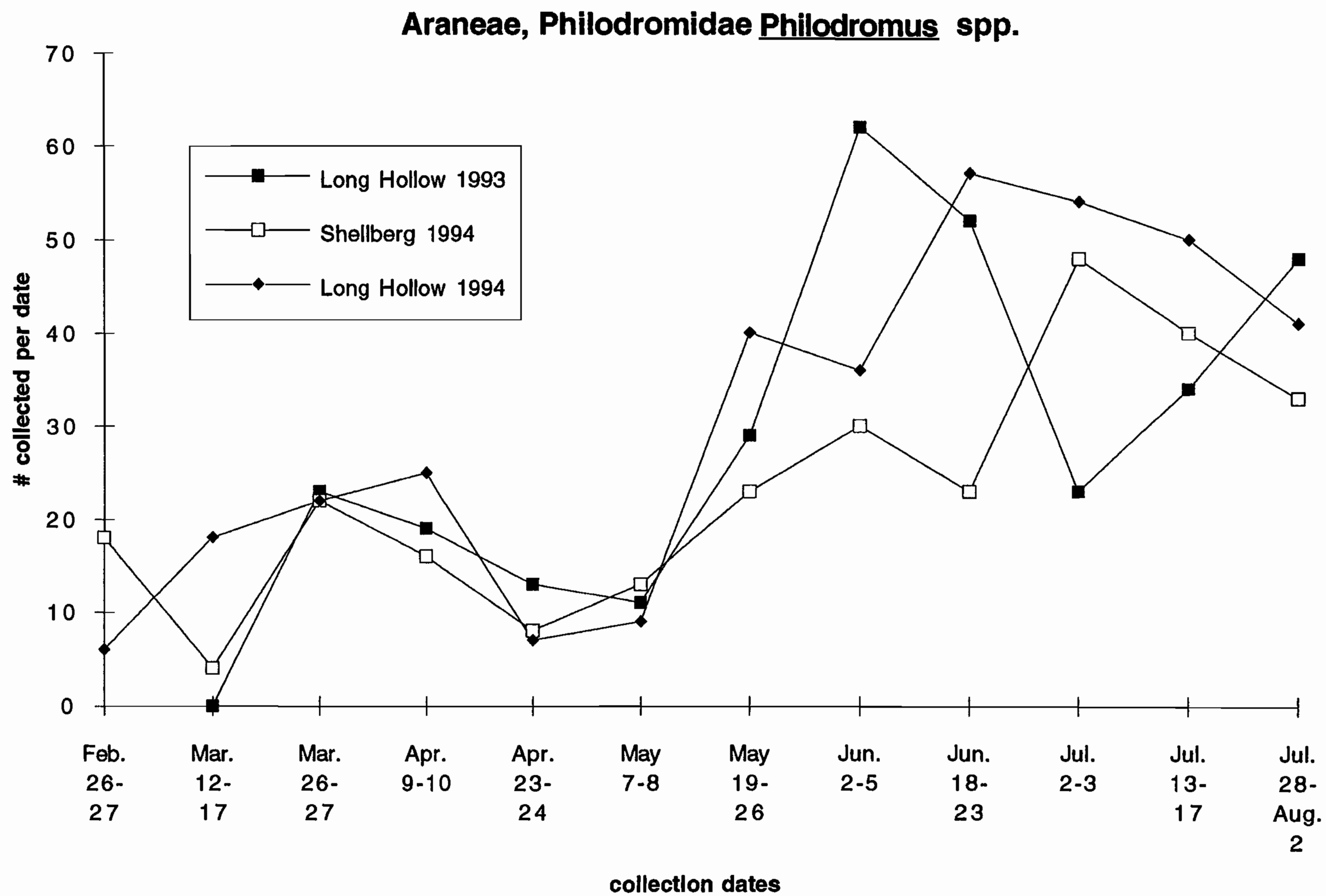

Araneae, Oxyopidae
Oxyopes scalaris
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
70
60
50
40
30
20
10
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 41



Araneae, Philodromidae Philodromus spp.
collected per date
70
60
50
40
30
20
10
0
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 42

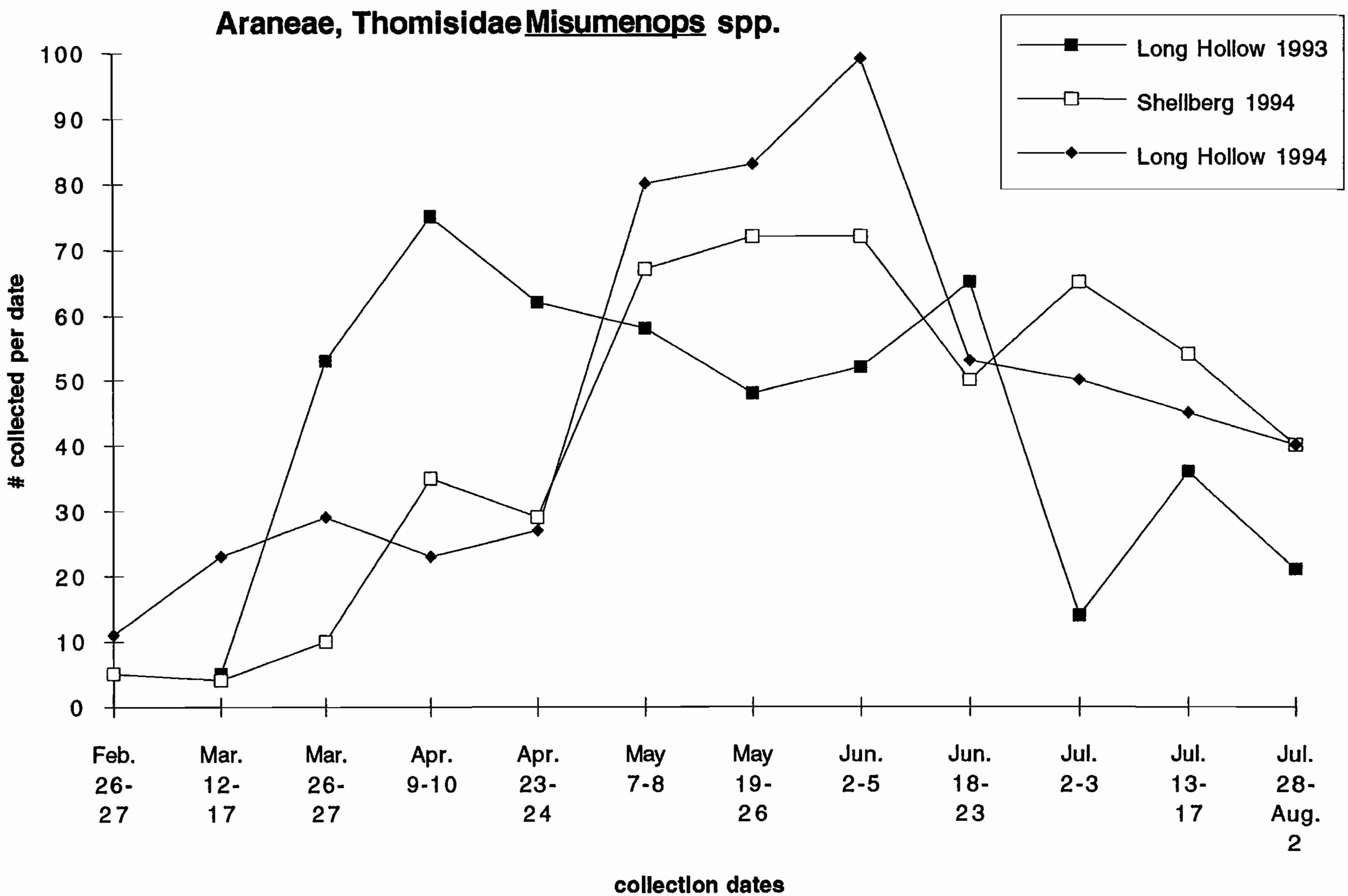

Araneae, Thomisidae Misumenops spp.
100
90
80
70
60
50
40
30
20
10
0
collected per date
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 43

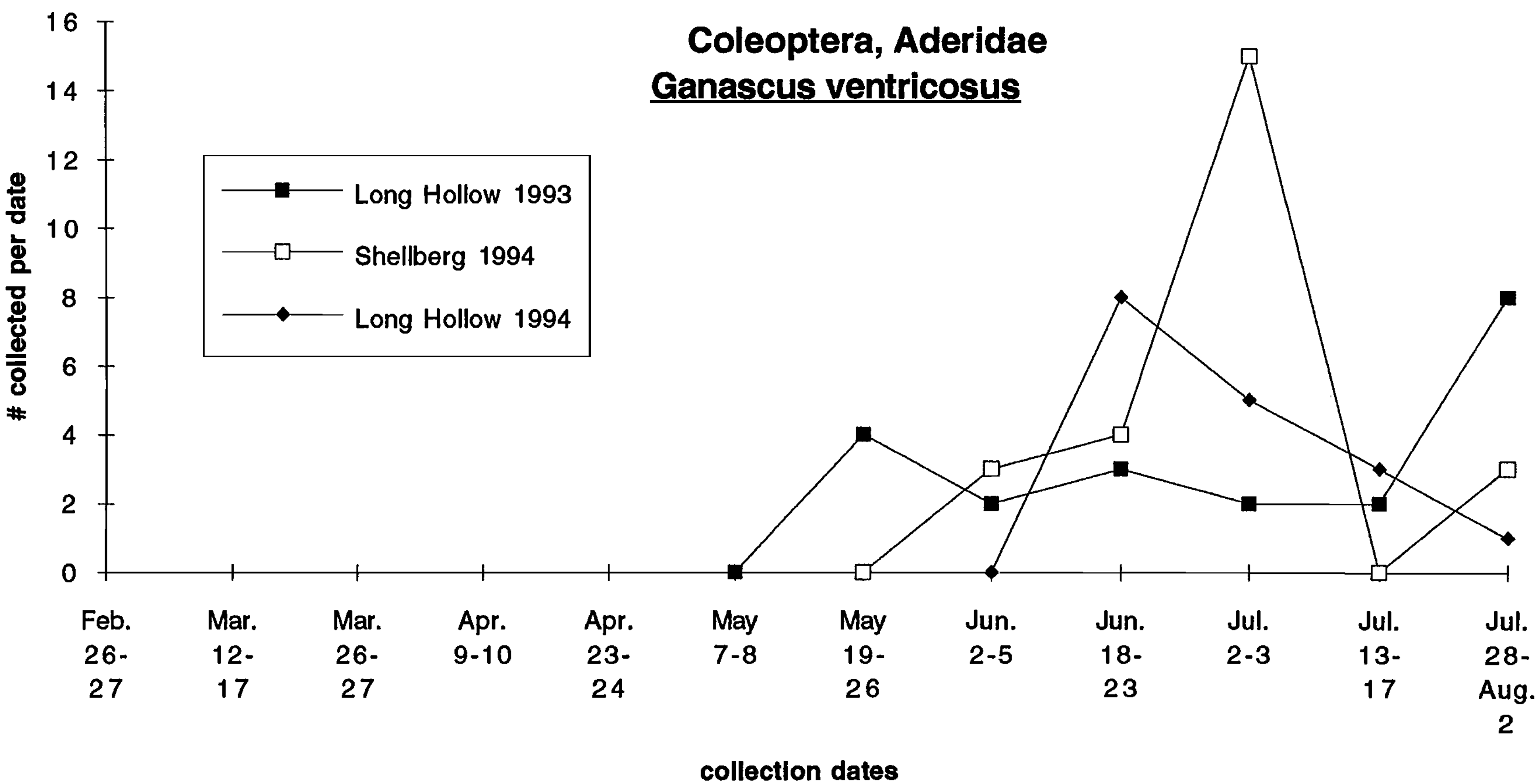
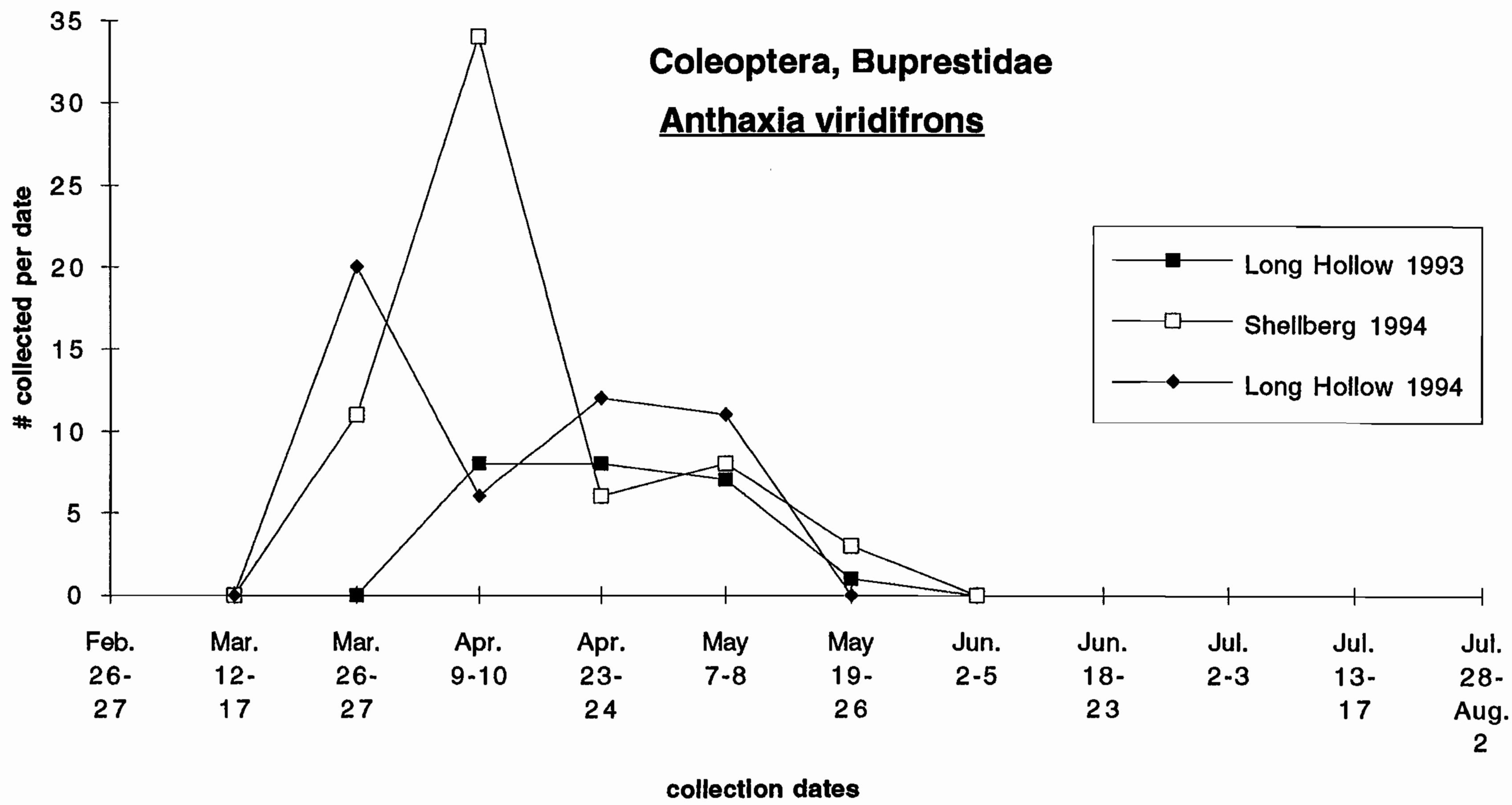
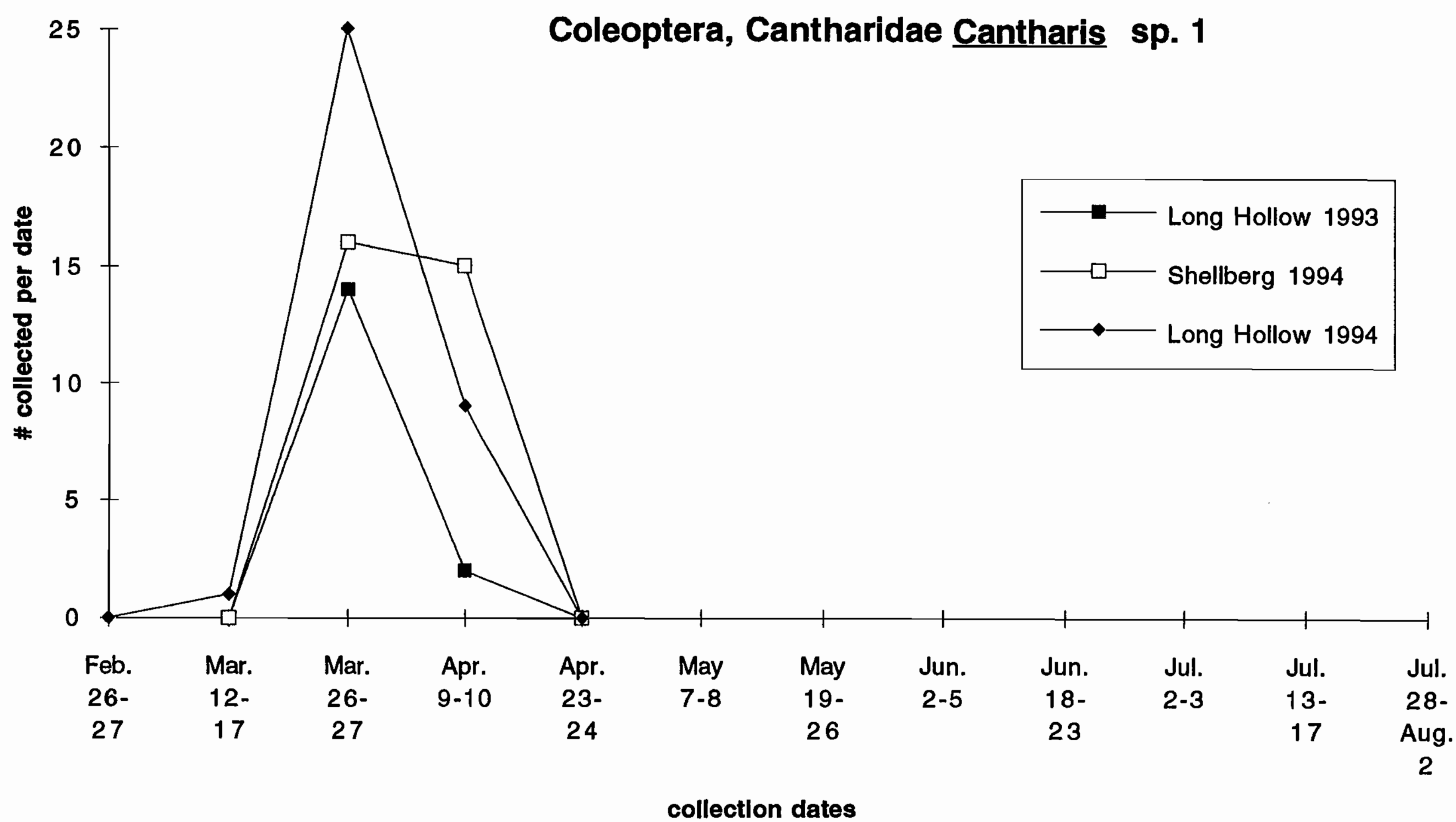

Coleoptera, Aderidae
Ganascus ventricosus
collected per date
0
2
4
6
8
10
12
14
16
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 44



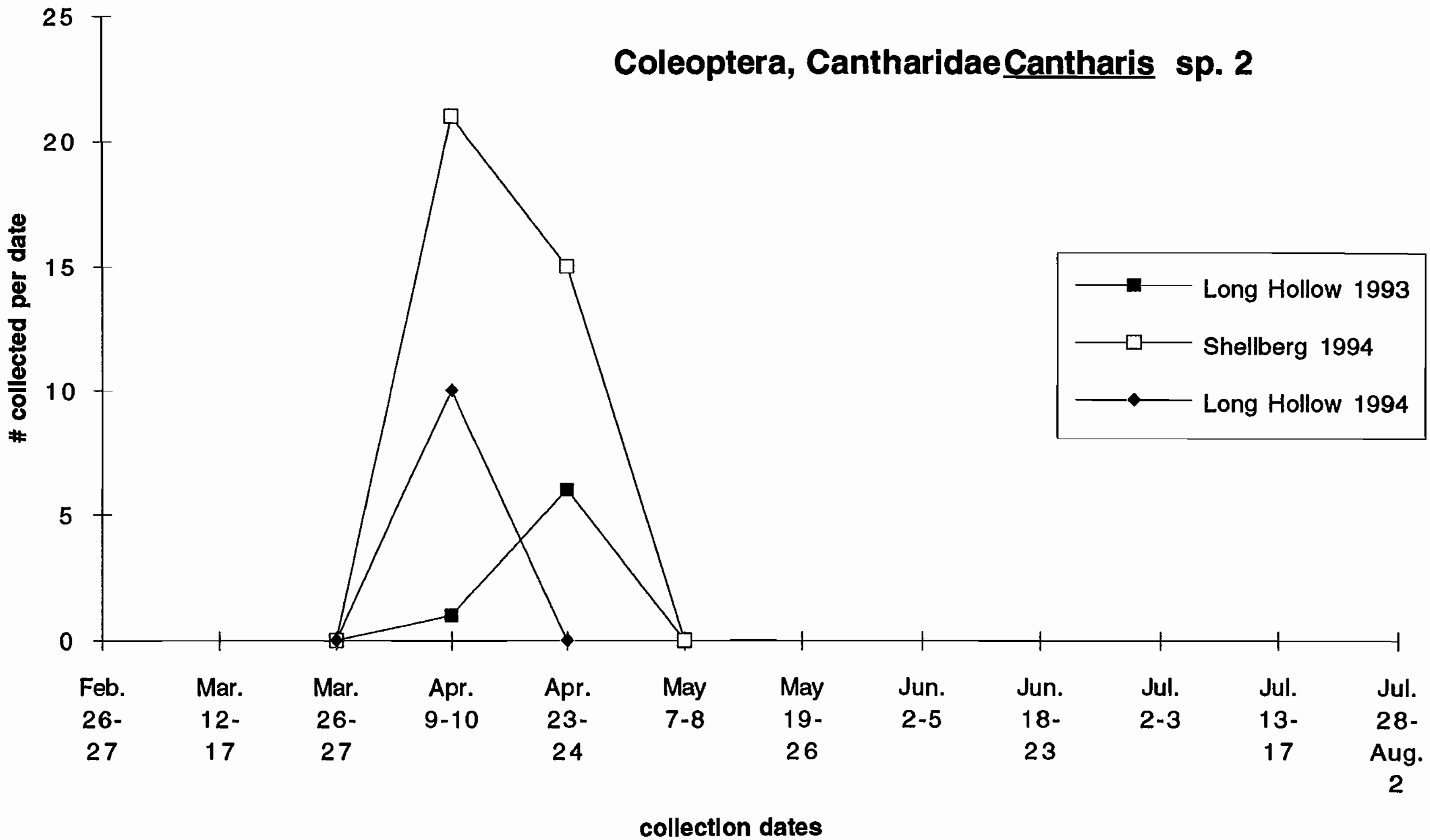
Coleoptera, Buprestidae
Anthaxia viridifrons
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
0
5
10
15
20
25
30
35
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 45



Coleoptera, Cantharidae Cantharis sp. 1
collected per date
0
5
10
15
20
25
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 46



Coleoptera, Cantharidae Cantharis sp. 2
collected per date
25
20
15
10
5
0
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 47

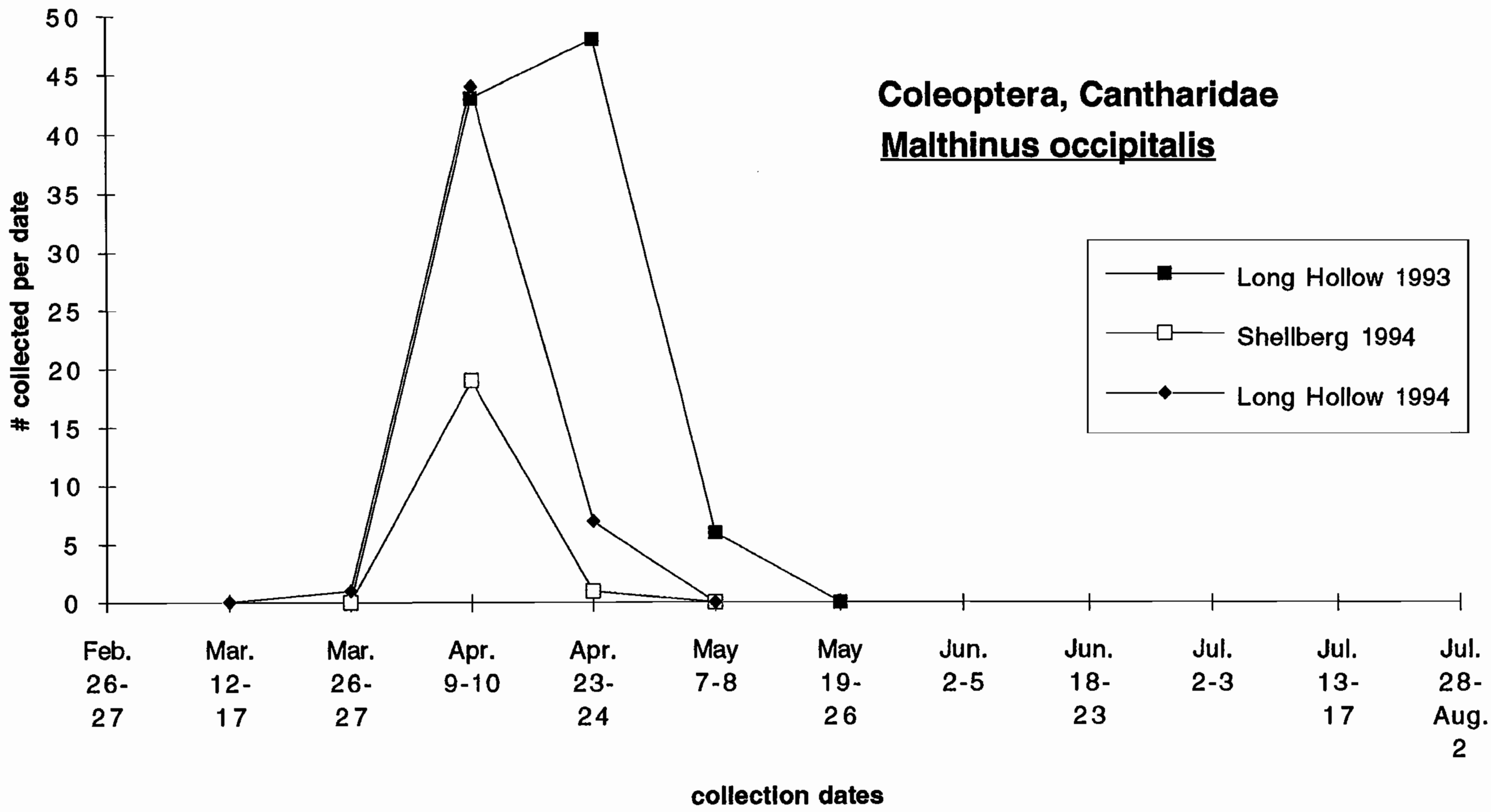

Coleoptera, Cantharidae
Malthinus occipitalis
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
0
5
10
15
20
25
30
35
40
45
50
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 48

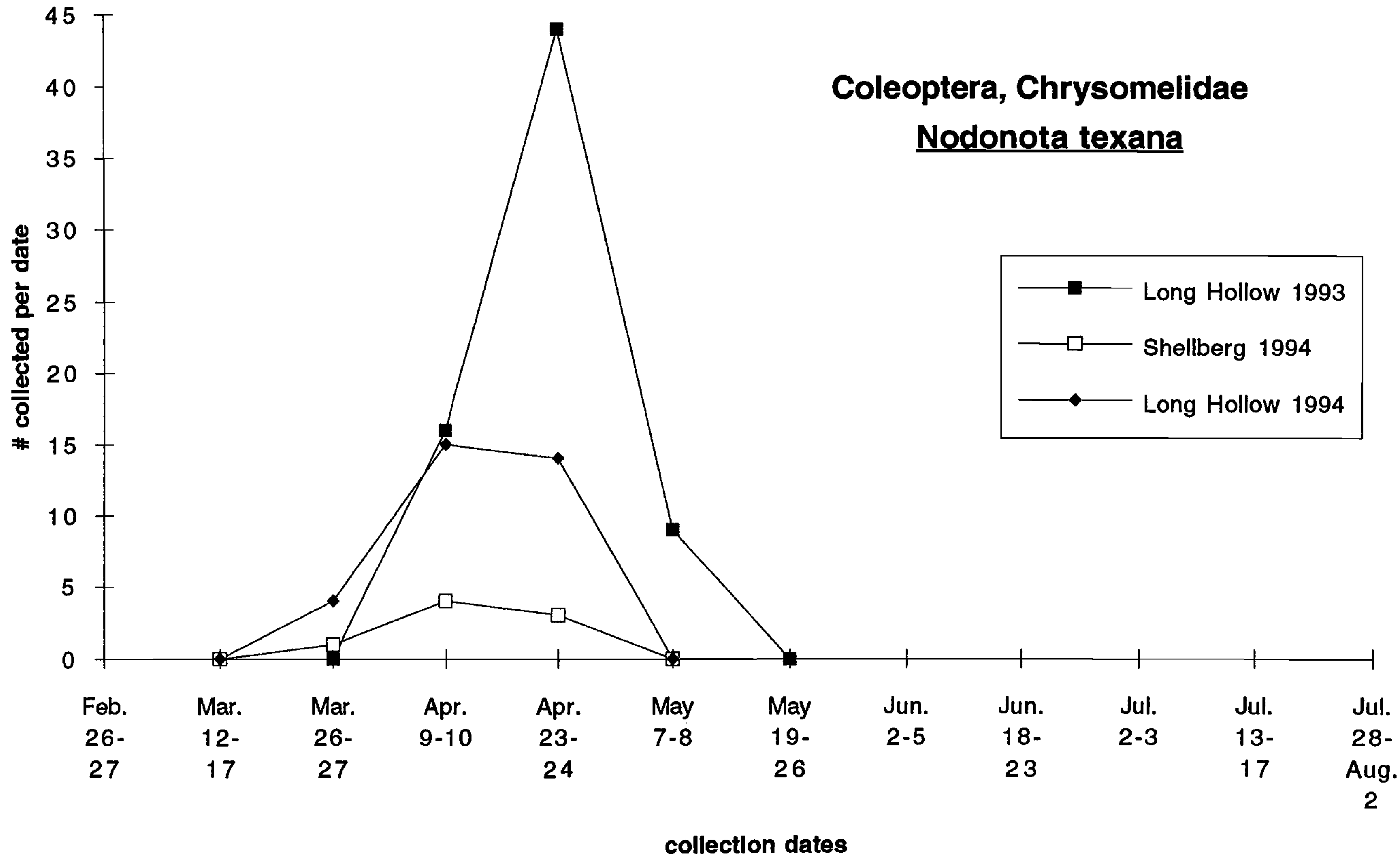

Coleoptera, Chrysomelidae
Nodonota texana
45
40
35
30
25
20
15
10
5
0
collected per date
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 49

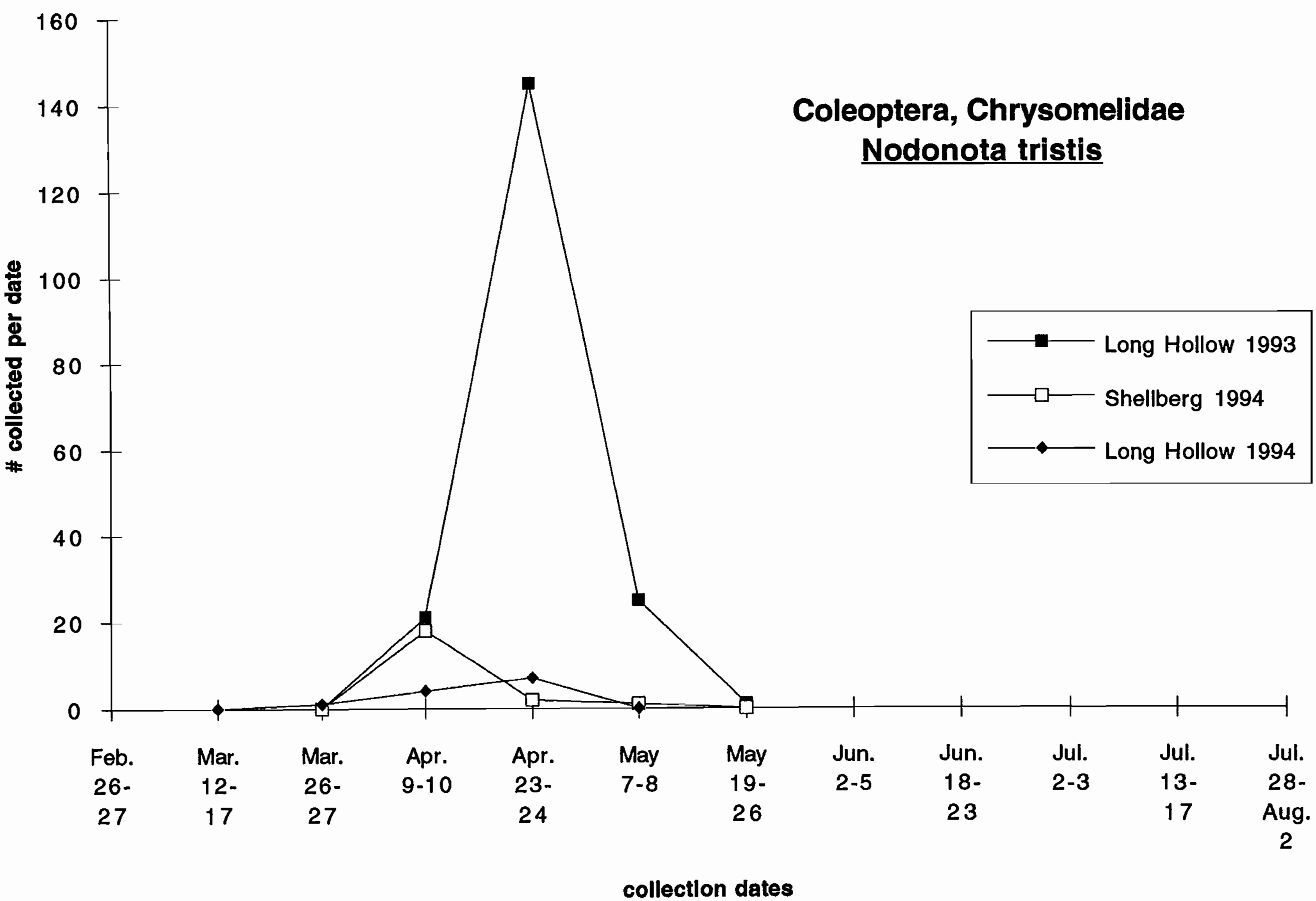

Coleoptera, Chrysomelidae
Nodonota tristis
collected per date
160
140
120
100
80
60
40
20
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates
Long Hollow 1993
Shellberg 1994
Long Hollow 1994

Figure 50

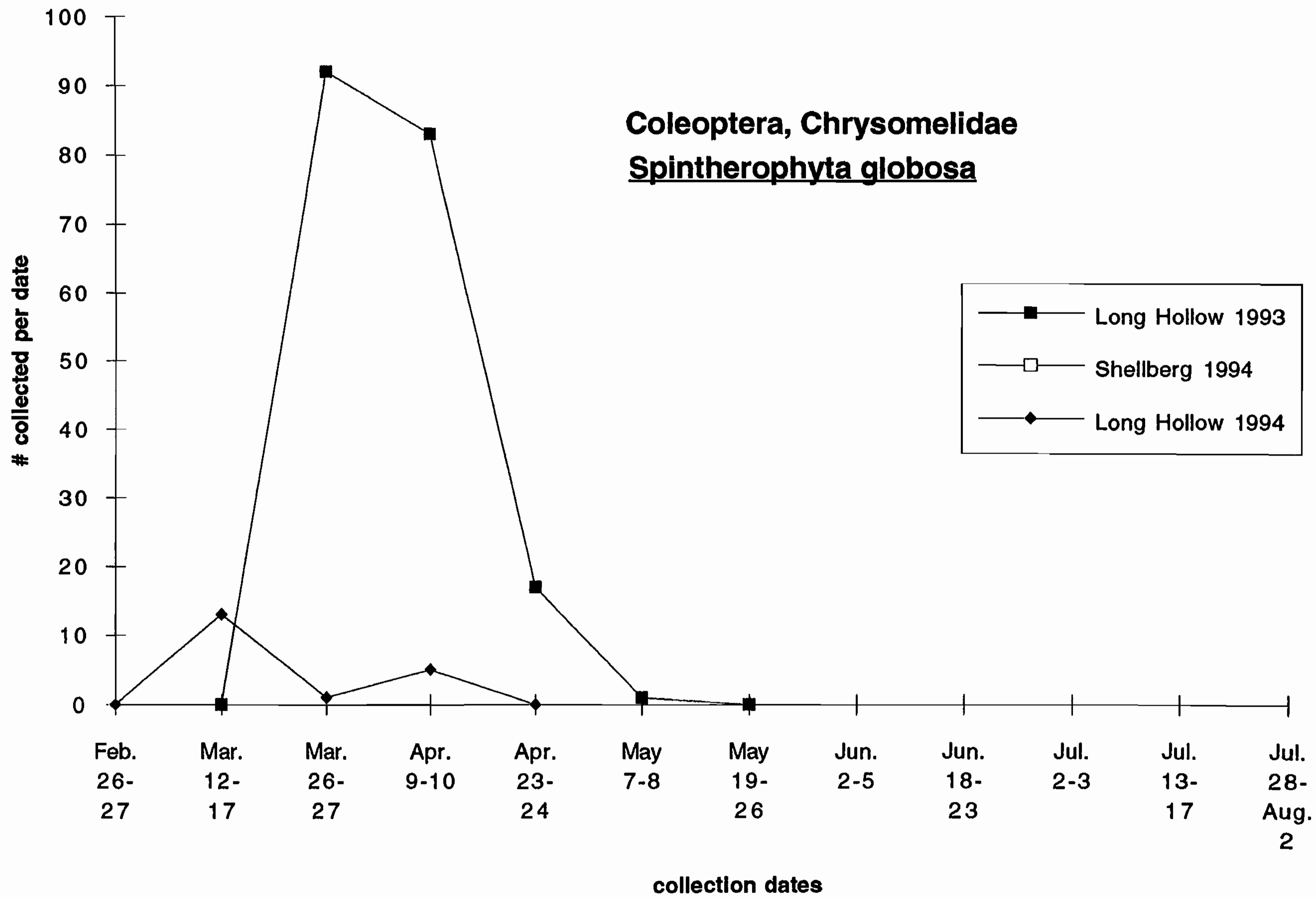
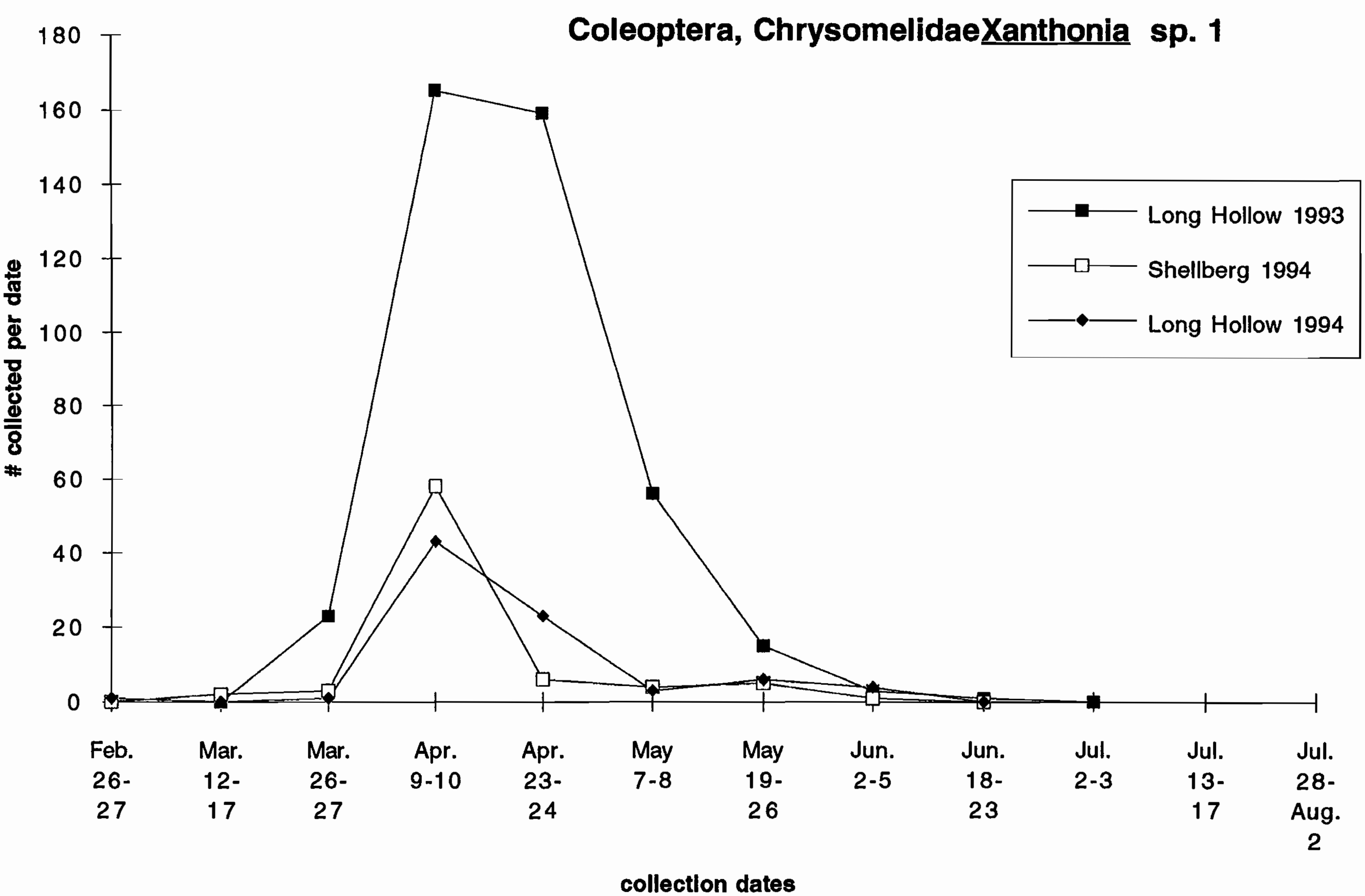

Coleoptera, Chrysomelidae
Spintherophyta globosa
collected per date
100
90
80
70
60
50
40
30
20
10
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates
Long Hollow 1993
Shellberg 1994
Long Hollow 1994

Figure 51



Coleoptera, ChrysomelidaeXanthonia sp. 1
collected per date
180
160
140
120
100
80
60
40
20
0
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 52

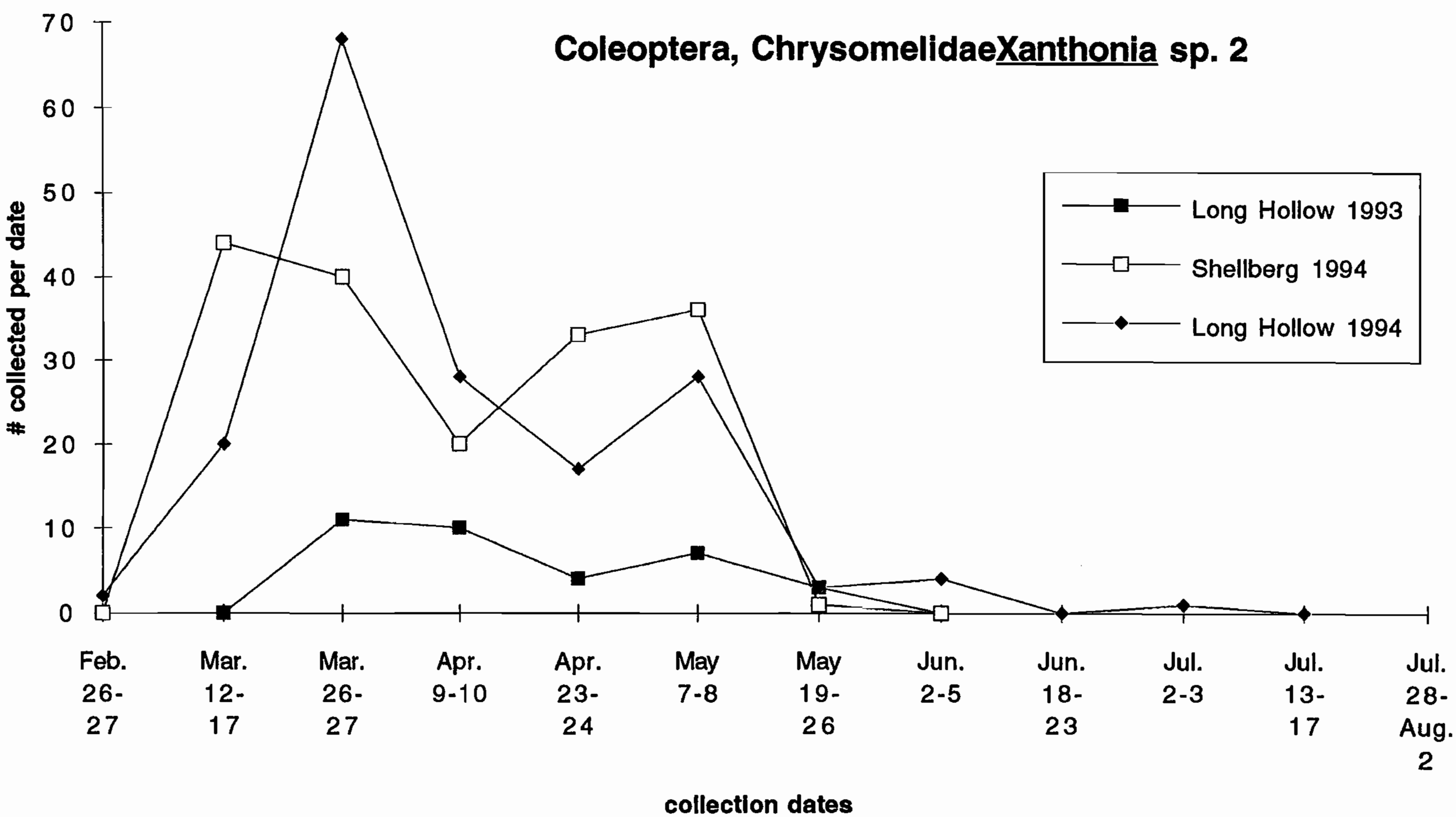
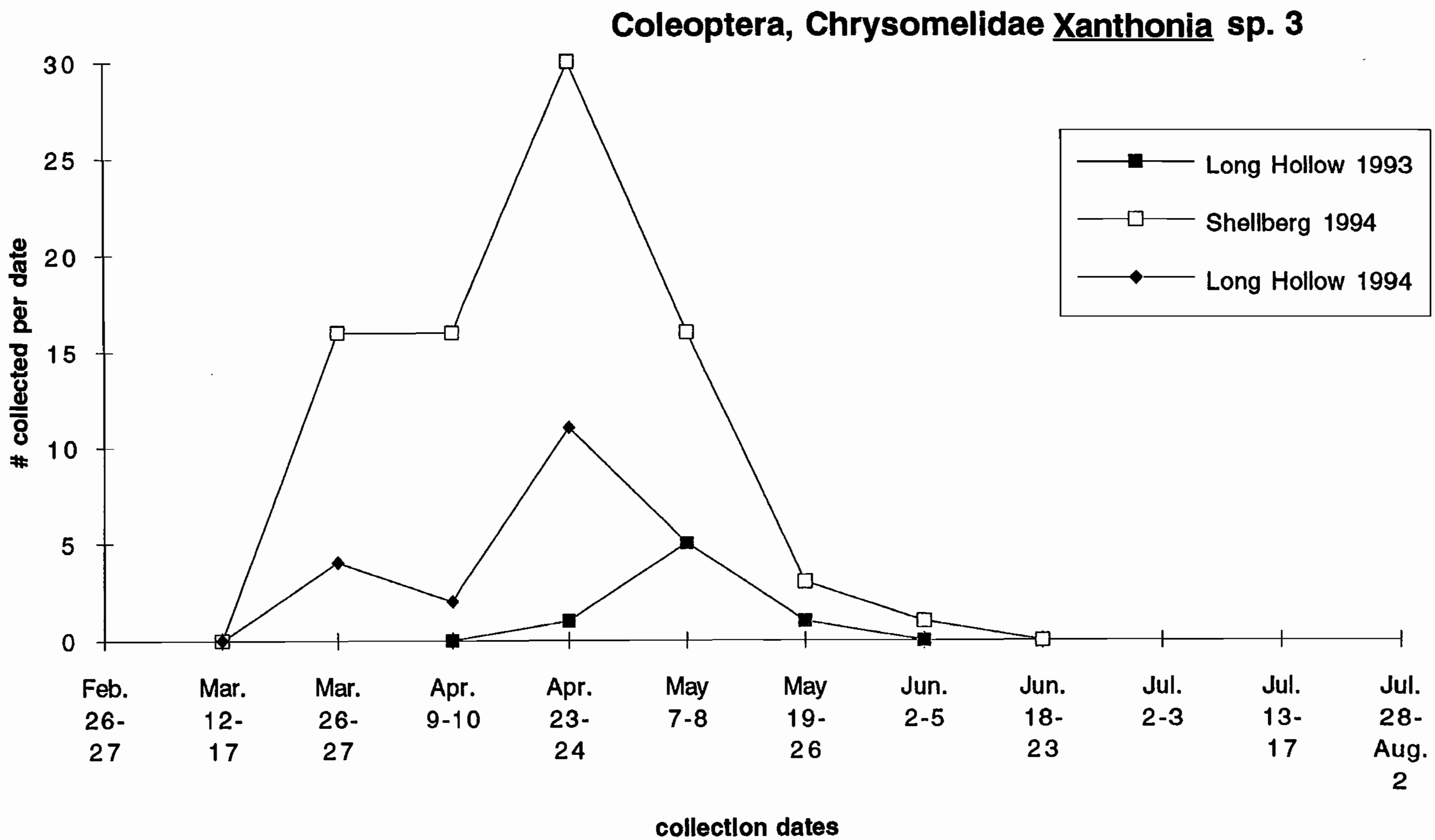

Coleoptera, ChrysomelidaeXanthonia sp. 2
collected per date
70
60
50
40
30
20
10
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates
Long Hollow 1993
Shellberg 1994
Long Hollow 1994

Figure 53



Coleoptera, Chrysomelidae Xanthonia sp. 3
30
25
20
15
10
5
0
collected per date
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 54

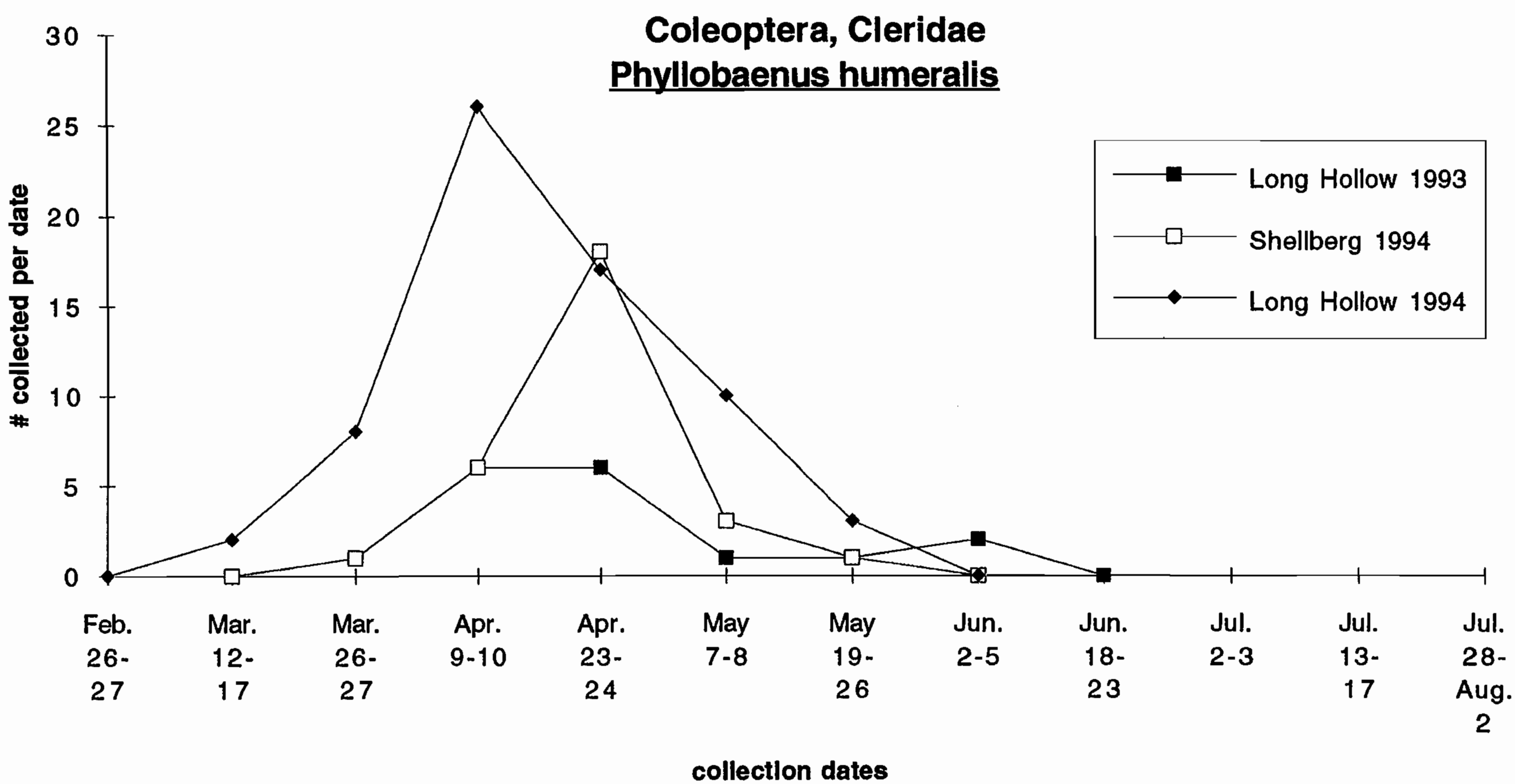
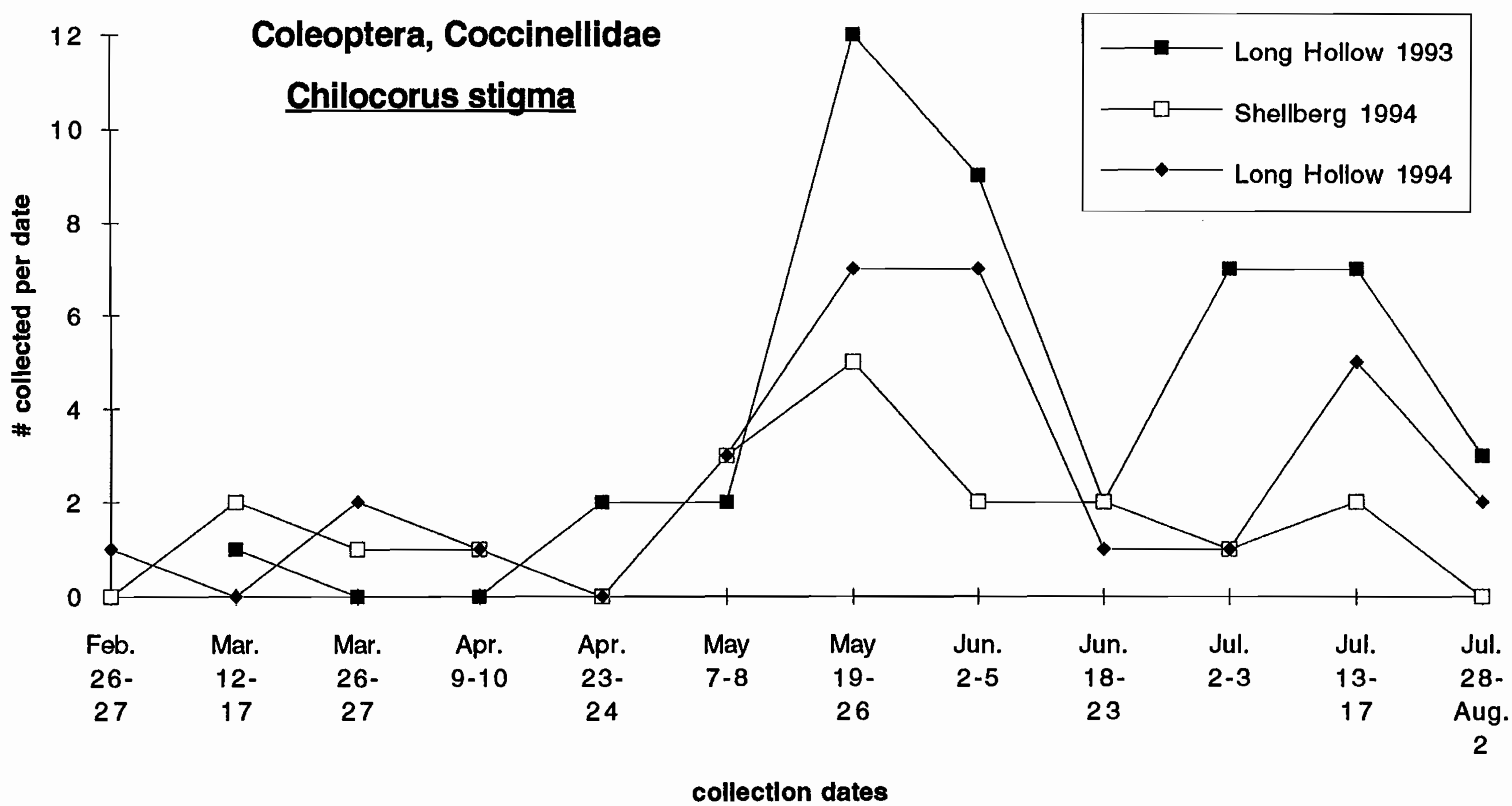
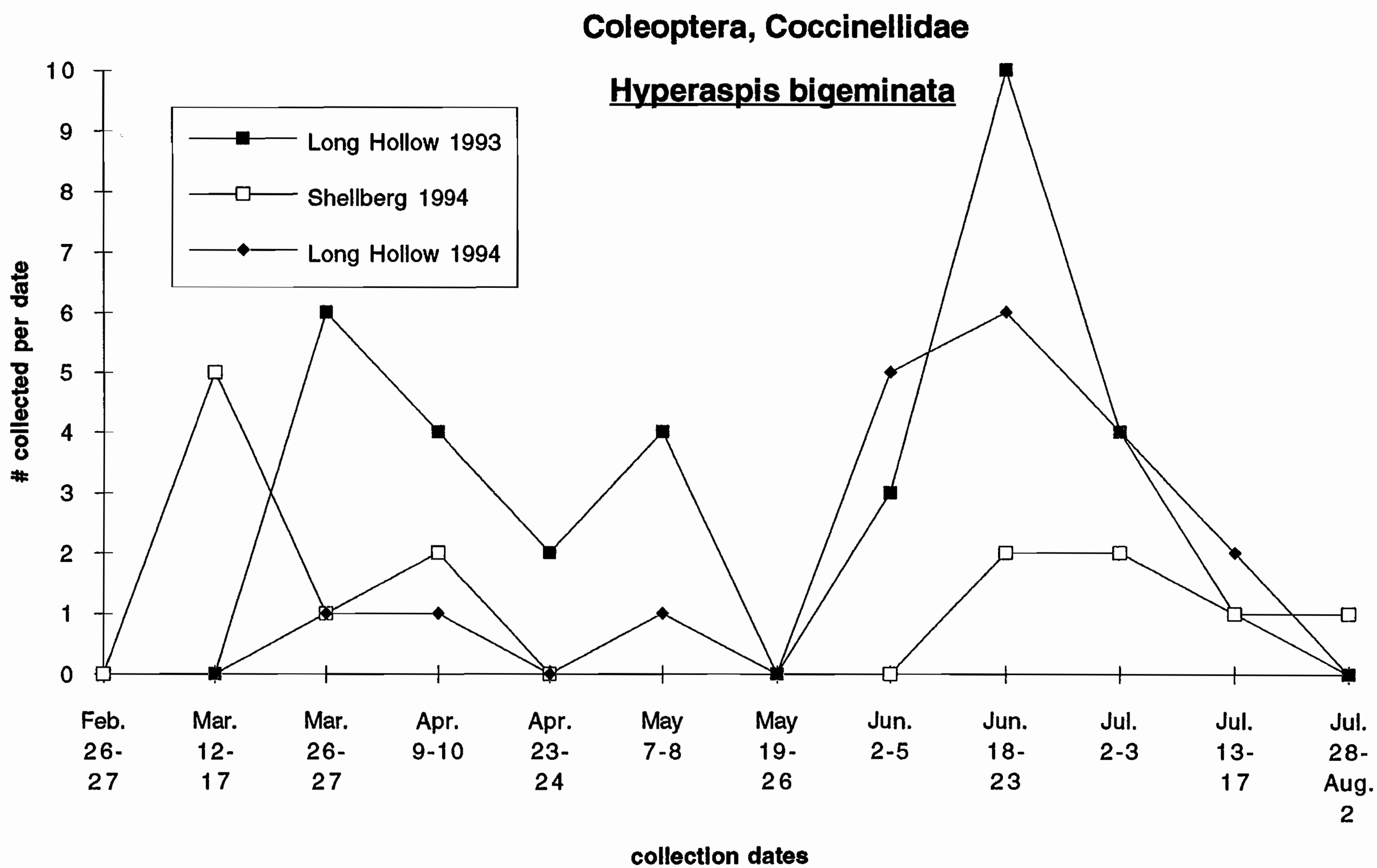

Coleoptera, Cleridae
Phyllobaenus humeralis
collected per date
30
25
20
15
10
5
0
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 55



Coleoptera, Coccinellidae
Chilocorus stigma
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
0
2
4
6
8
10
12
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 56



Coleoptera, Coccinellidae
Hyperaspis bigeminata
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
10
9
8
7
6
5
4
3
2
1
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 57

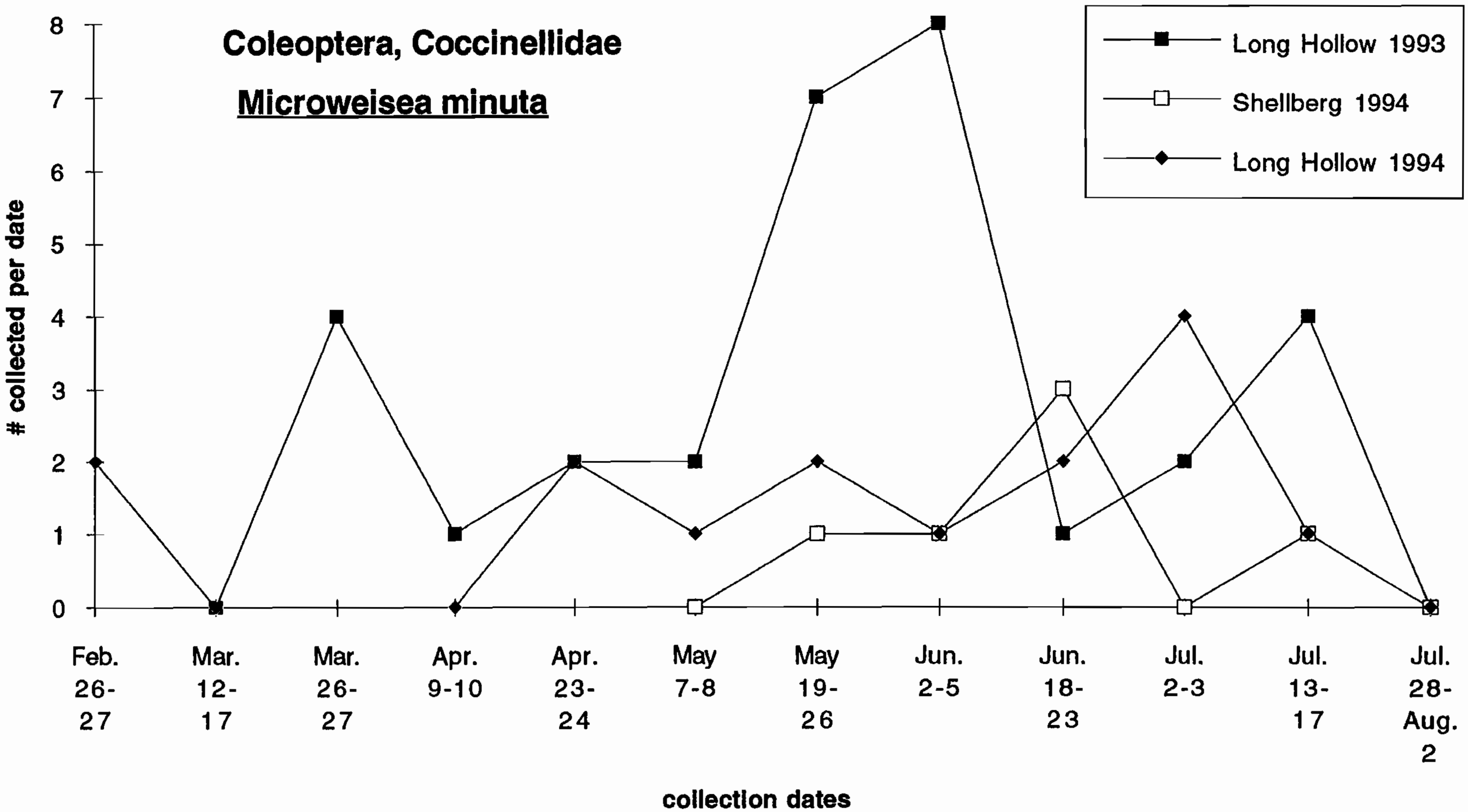
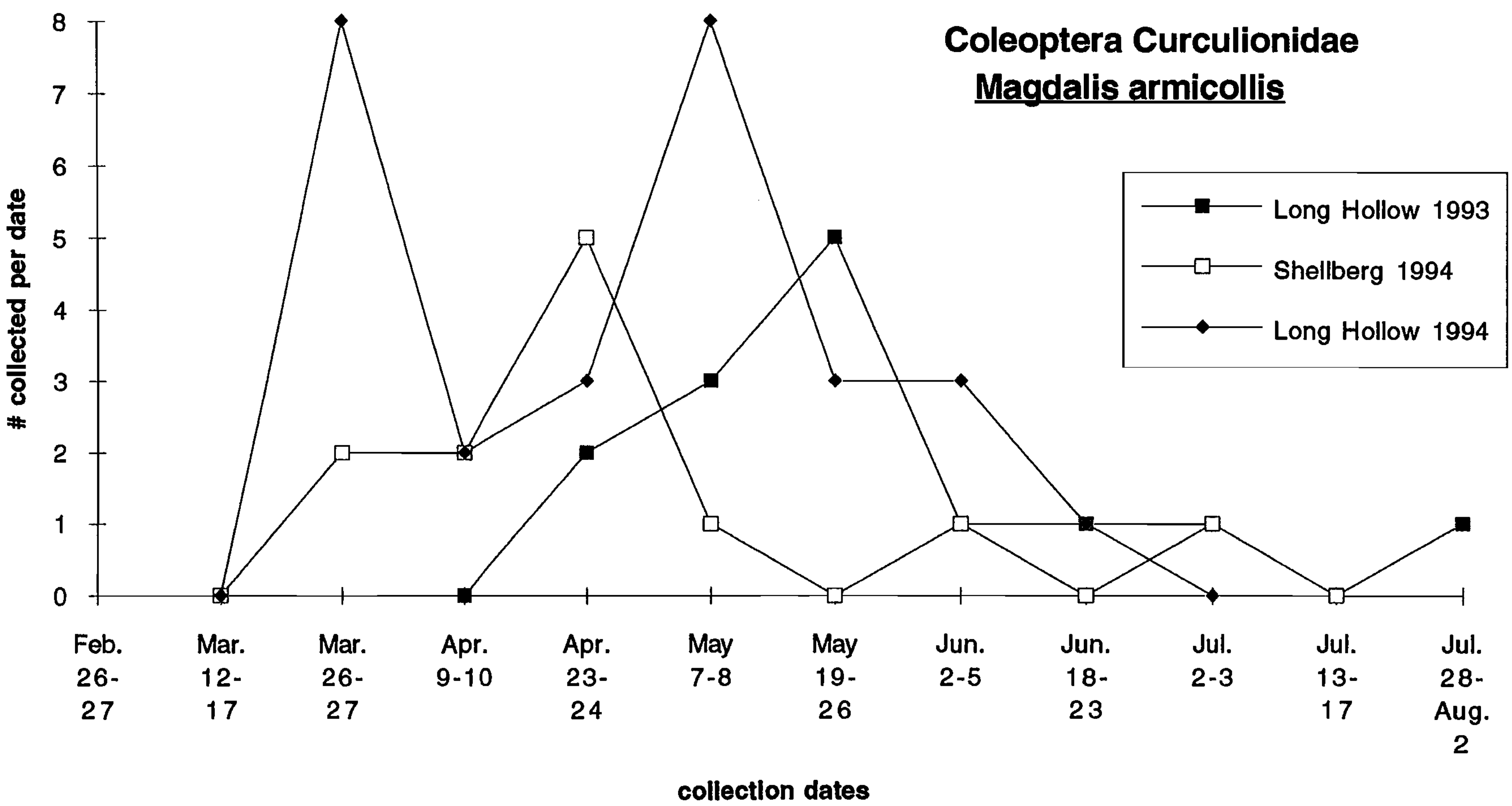

Coleoptera, Coccinellidae
Microweisea minuta
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
0
1
2
3
4
5
6
7
8
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 58



Coleoptera Curculionidae
Magdalis armicollis
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
0
1
2
3
4
5
6
7
8
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 59

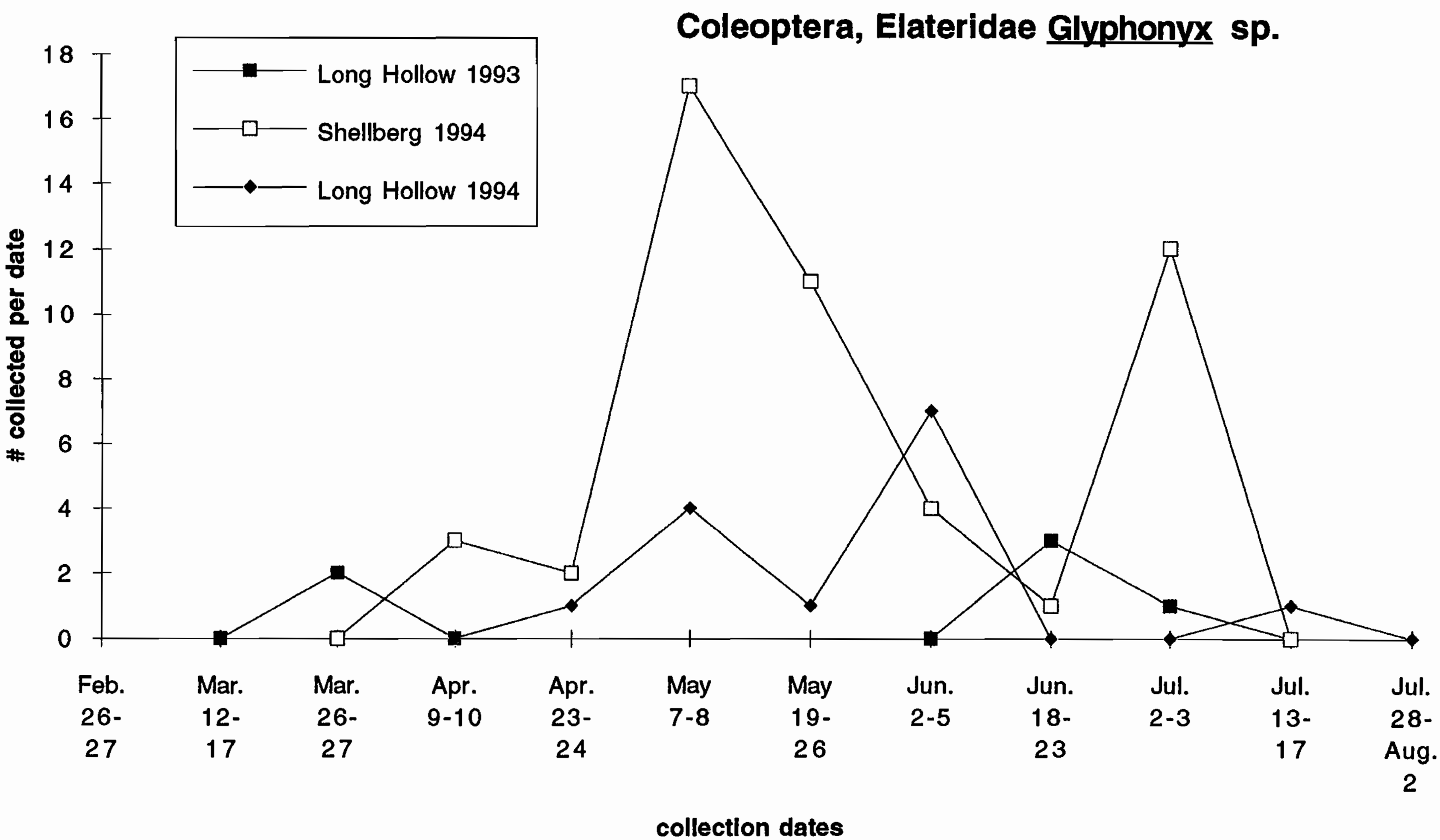

Coleoptera, Elateridae Glyphonyx sp.
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
18
16
14
12
10
8
6
4
2
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 60

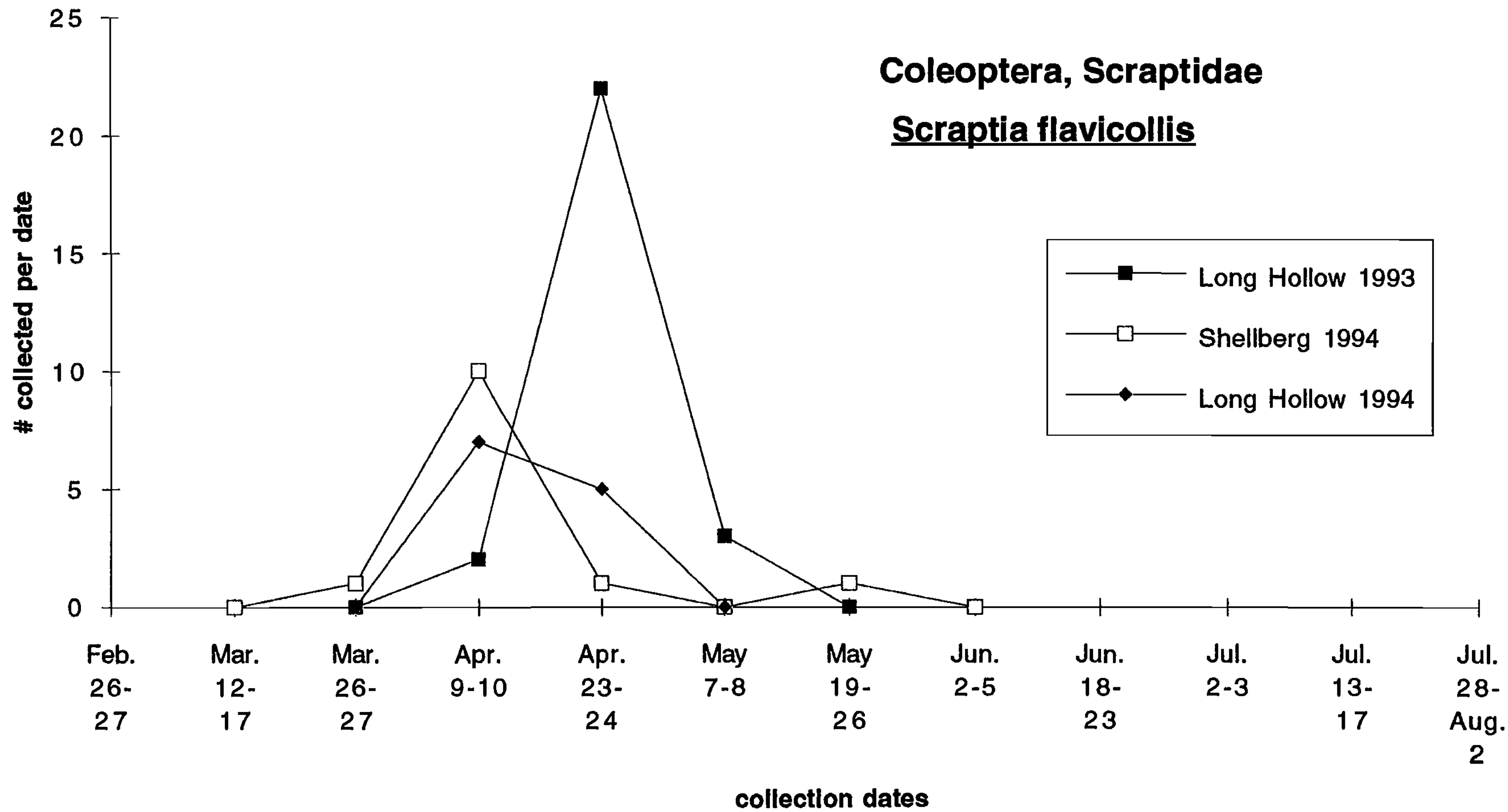
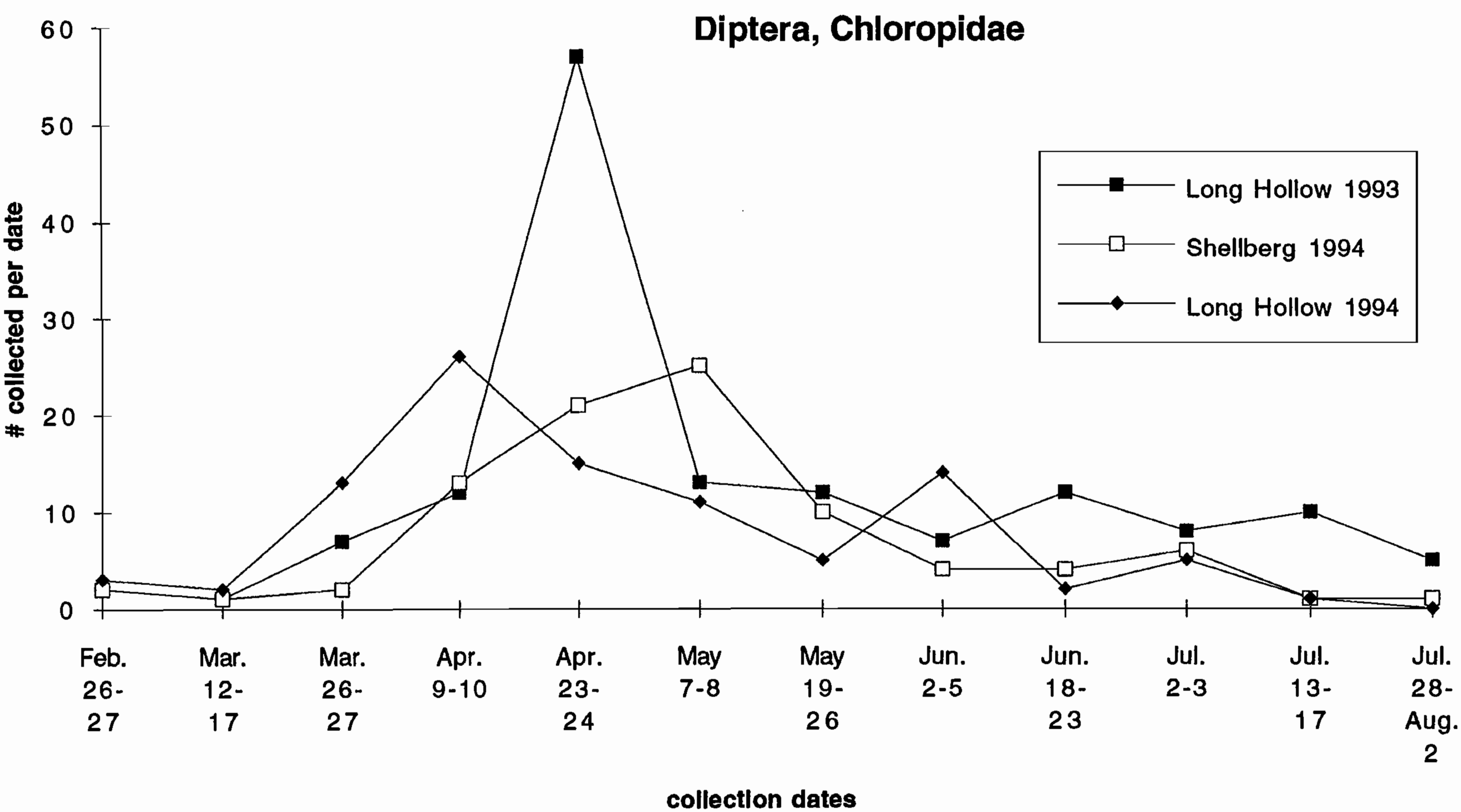

Coleoptera, Scraptidae
Scraptia flavicollis
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
25
20
15
10
5
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 61



Diptera, Chloropidae
60
50
40
30
20
10
0
collected per date
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 62

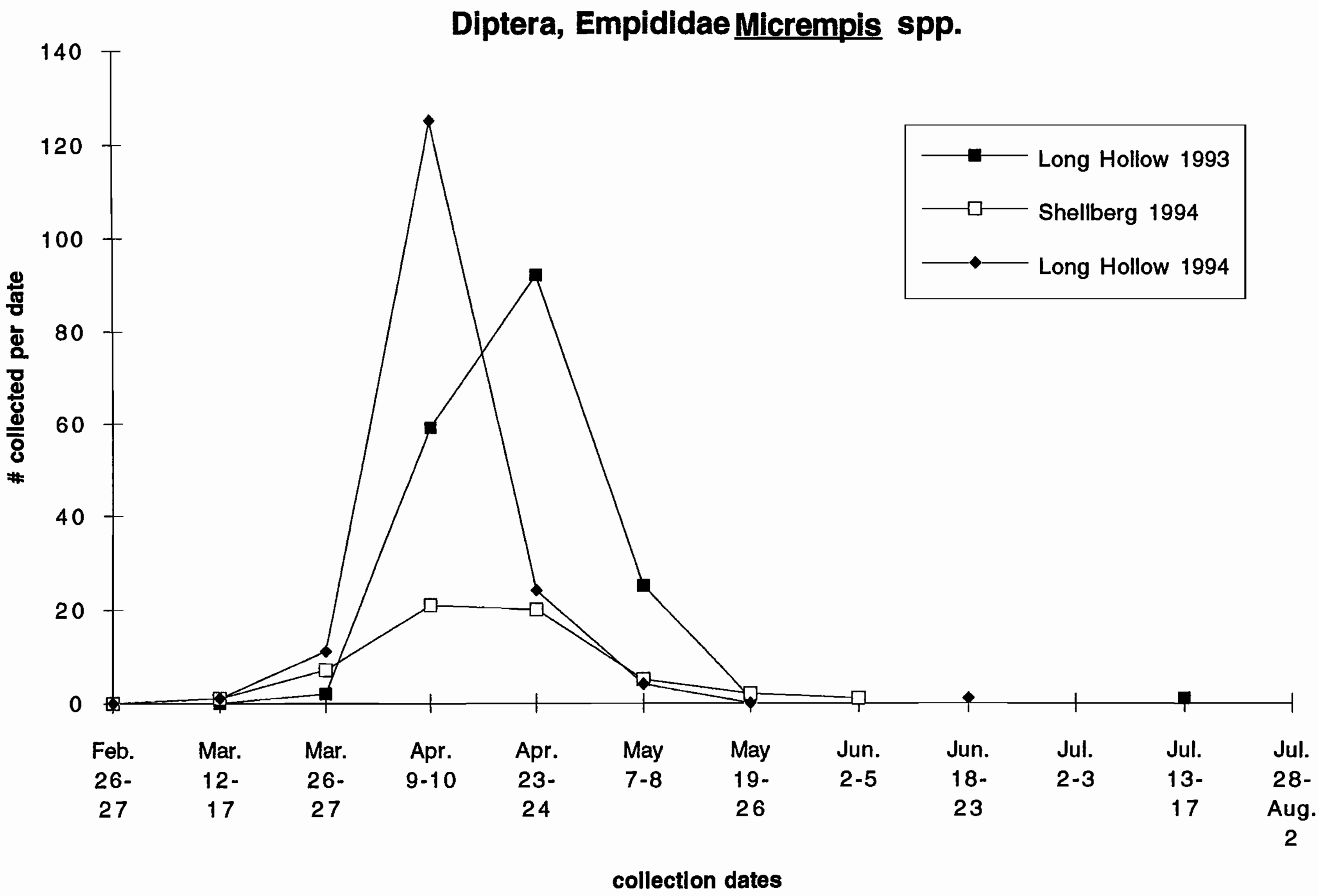

Diptera, Empididae Micrempis spp.
collected per date
140
120
100
80
60
40
20
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates
Long Hollow 1993
Shellberg 1994
Long Hollow 1994

Figure 63

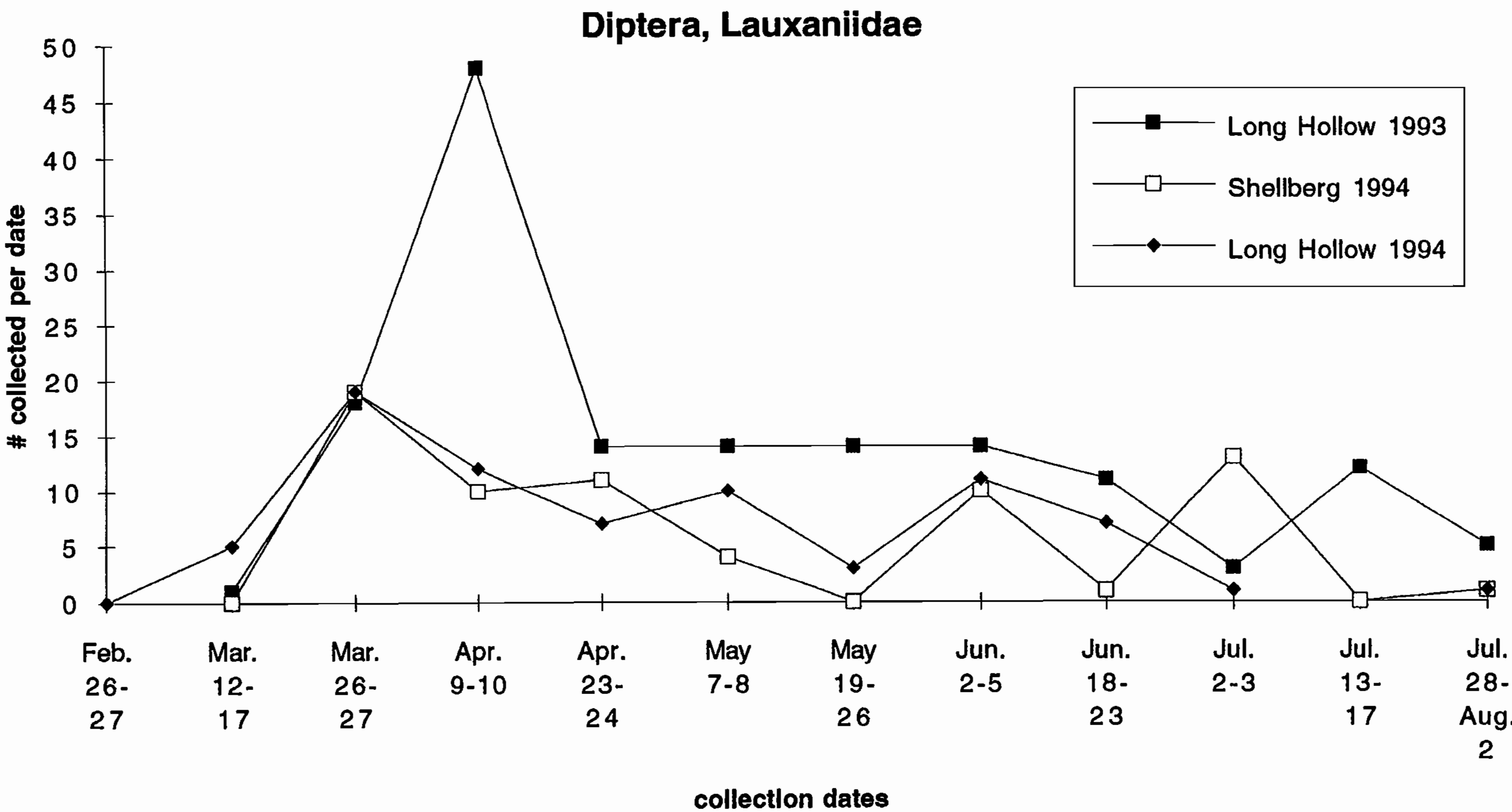

Diptera, Lauxaniidae
collected per date
50
45
40
35
30
25
20
15
10
5
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates
Long Hollow 1993
Shellberg 1994
Long Hollow 1994

Figure 64

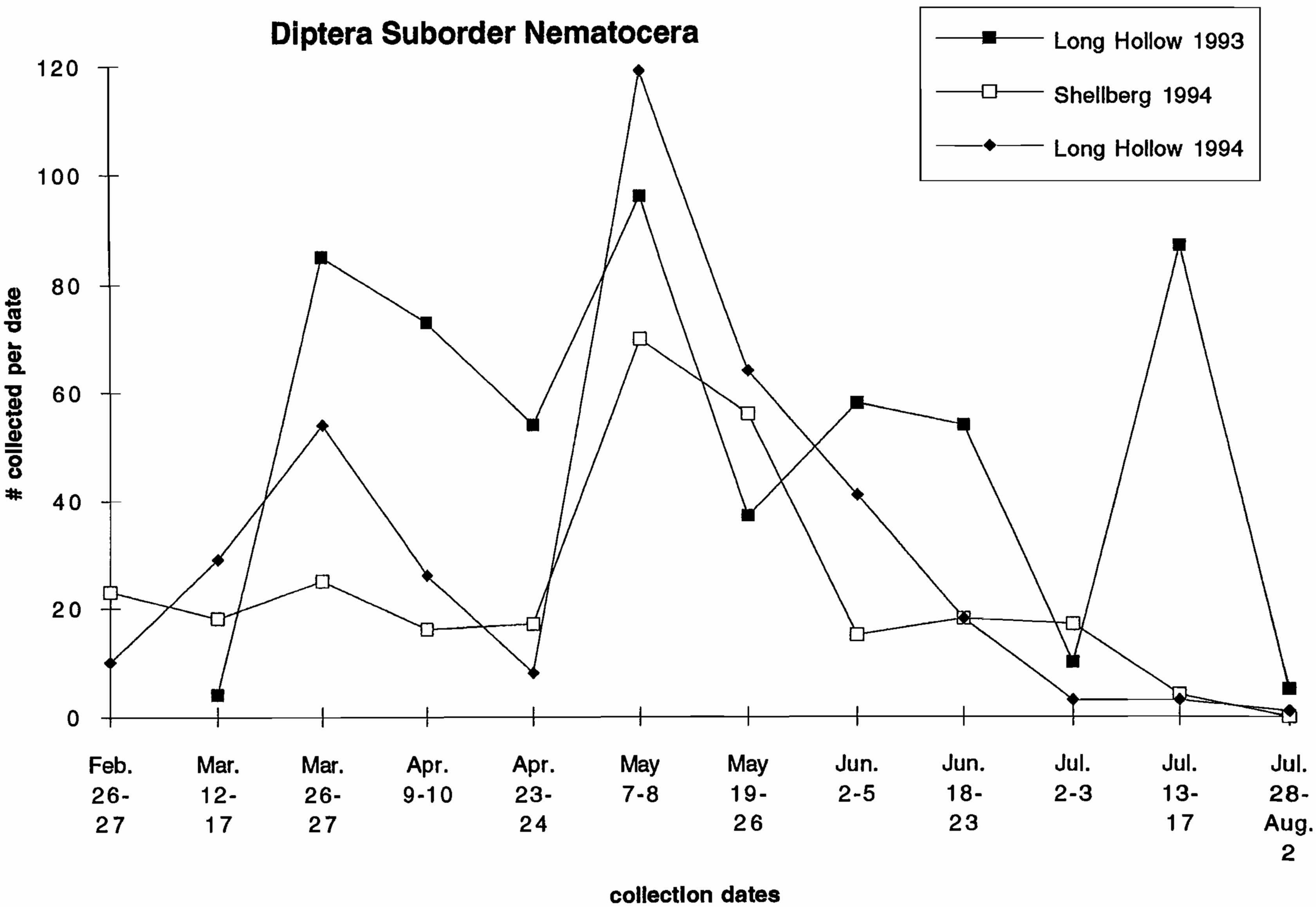
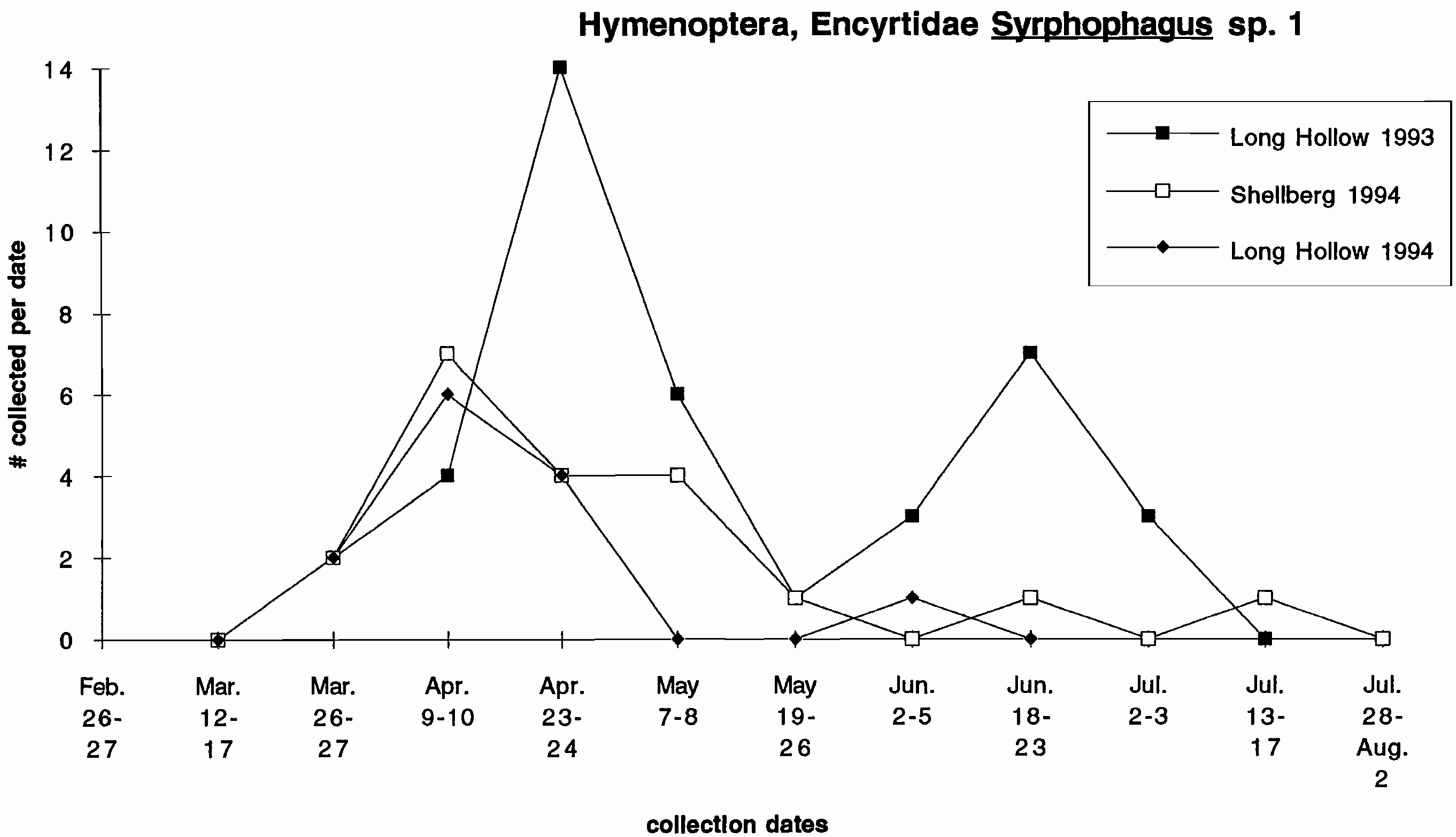

Diptera Suborder Nematocera
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
120
100
80
60
40
20
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 65



Hymenoptera, Encyrtidae Syrphophagus sp. 1
collected per date
14
12
10
8
6
4
2
0
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 66

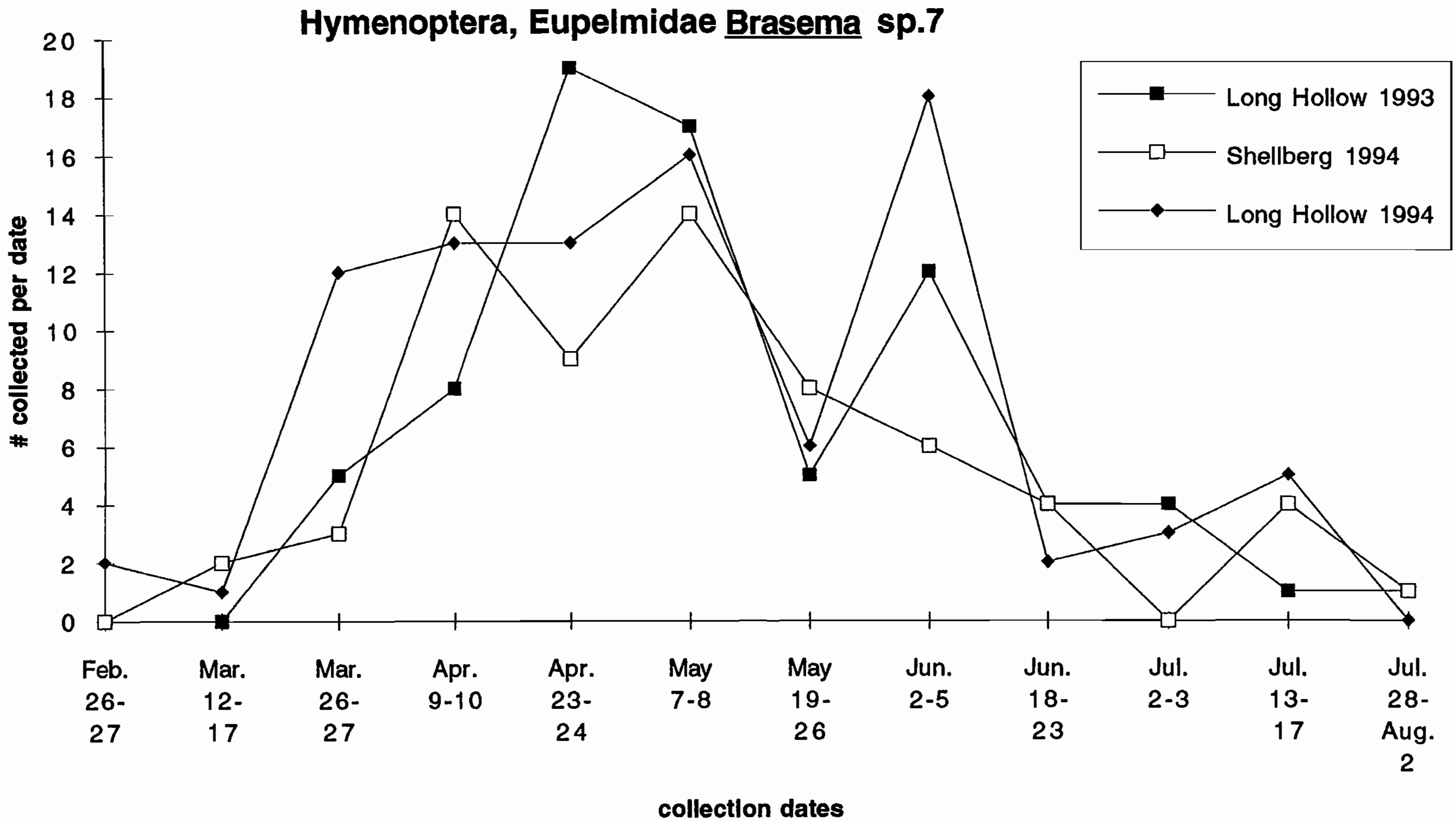
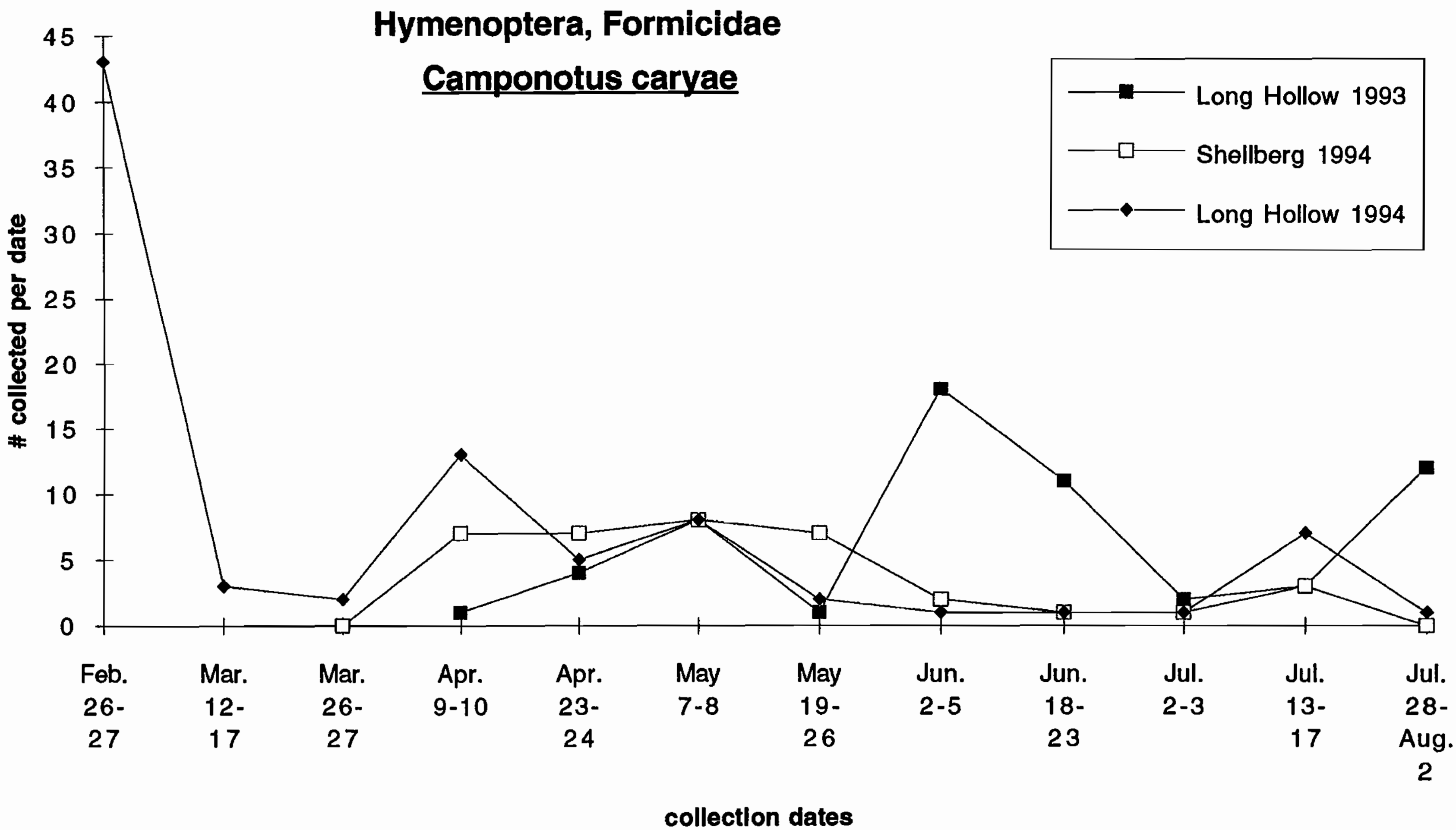
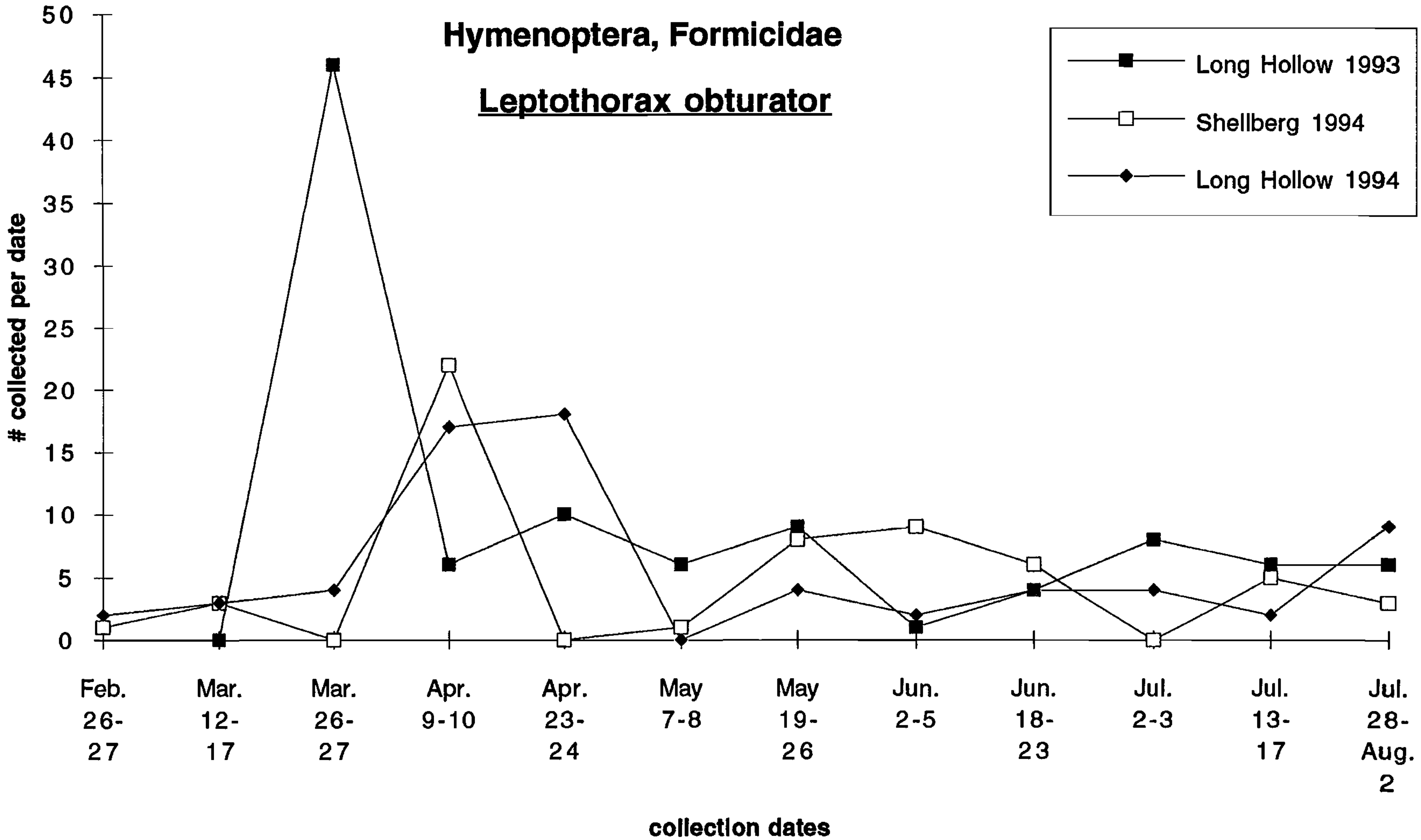

Hymenoptera, Eupelmidae Brasema sp.7
collected per date
20
18
16
14
12
10
8
6
4
2
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates
Long Hollow 1993
Shellberg 1994
Long Hollow 1994

Figure 67



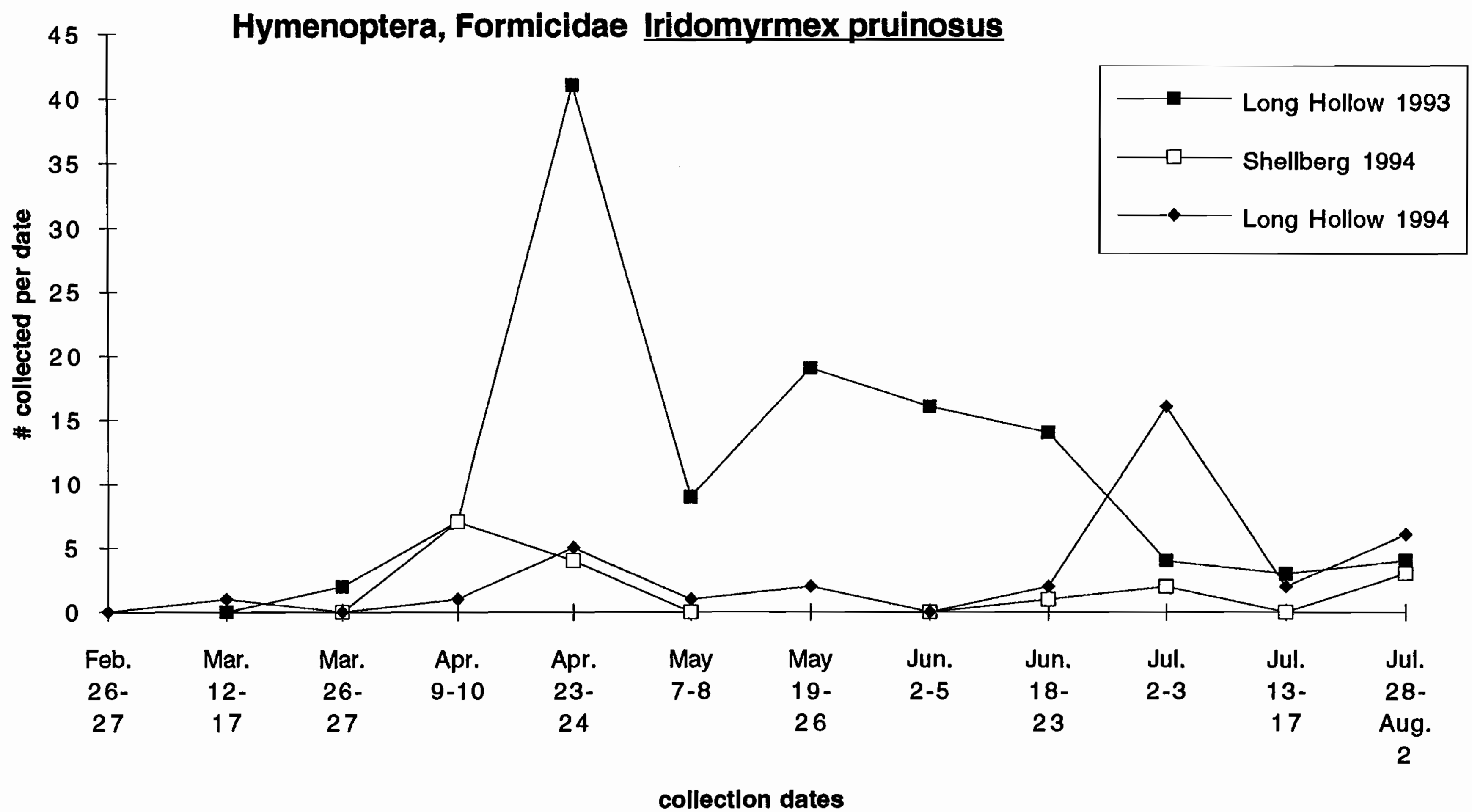
Hymenoptera, Formicidae
Camponotus caryae
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
0
5
10
15
20
25
30
35
40
45
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 68



Hymenoptera, Formicidae
Leptothorax obturator
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
50
45
40
35
30
25
20
15
10
5
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 69



Hymenoptera, Formicidae Iridomyrmex pruinosus
collected per date
45
40
35
30
25
20
15
10
5
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates
Long Hollow 1993
Shellberg 1994
Long Hollow 1994

Figure 70

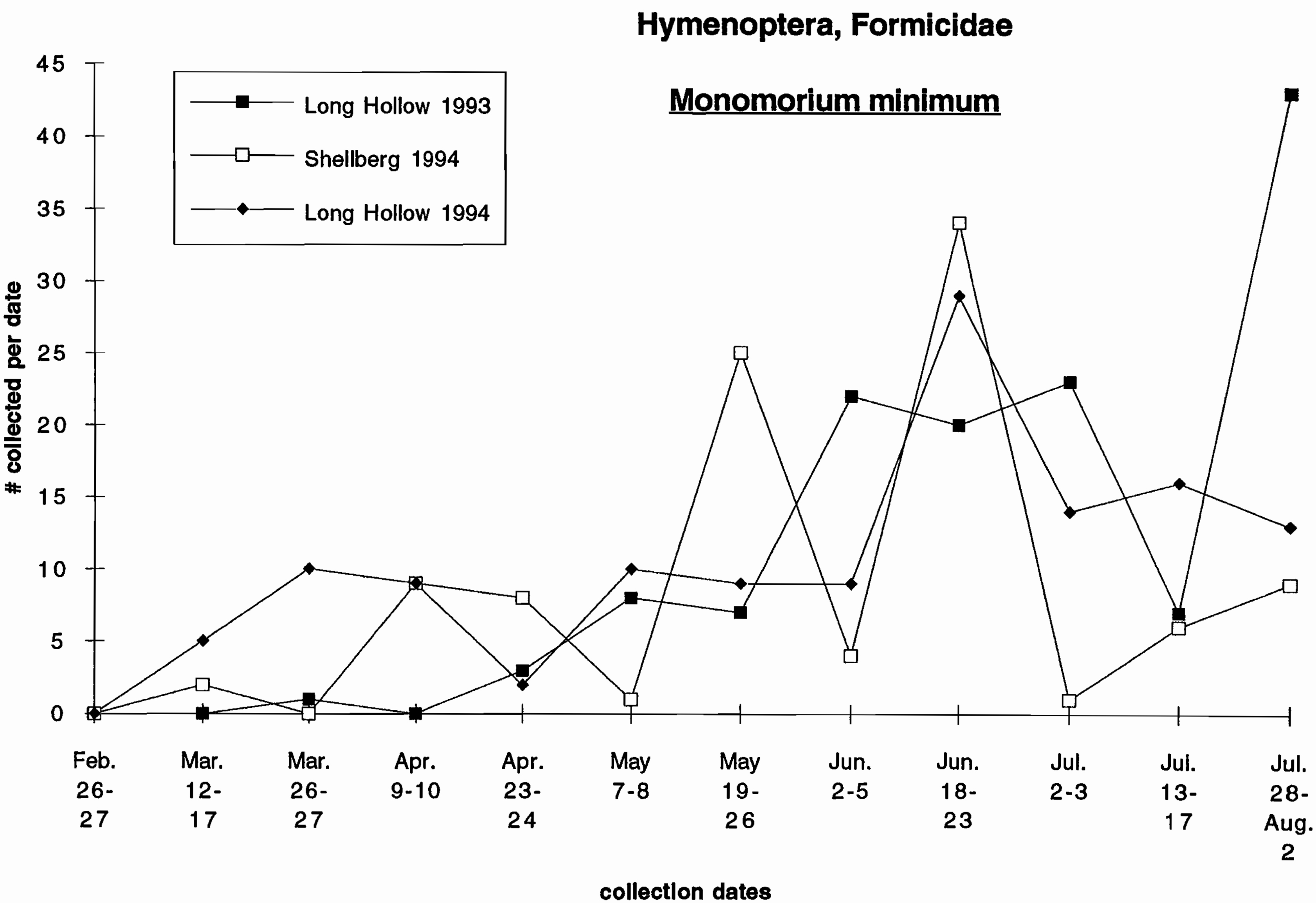

Hymenoptera, Formicidae
Monomorium minimum
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
0
5
10
15
20
25
30
35
40
45
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 71

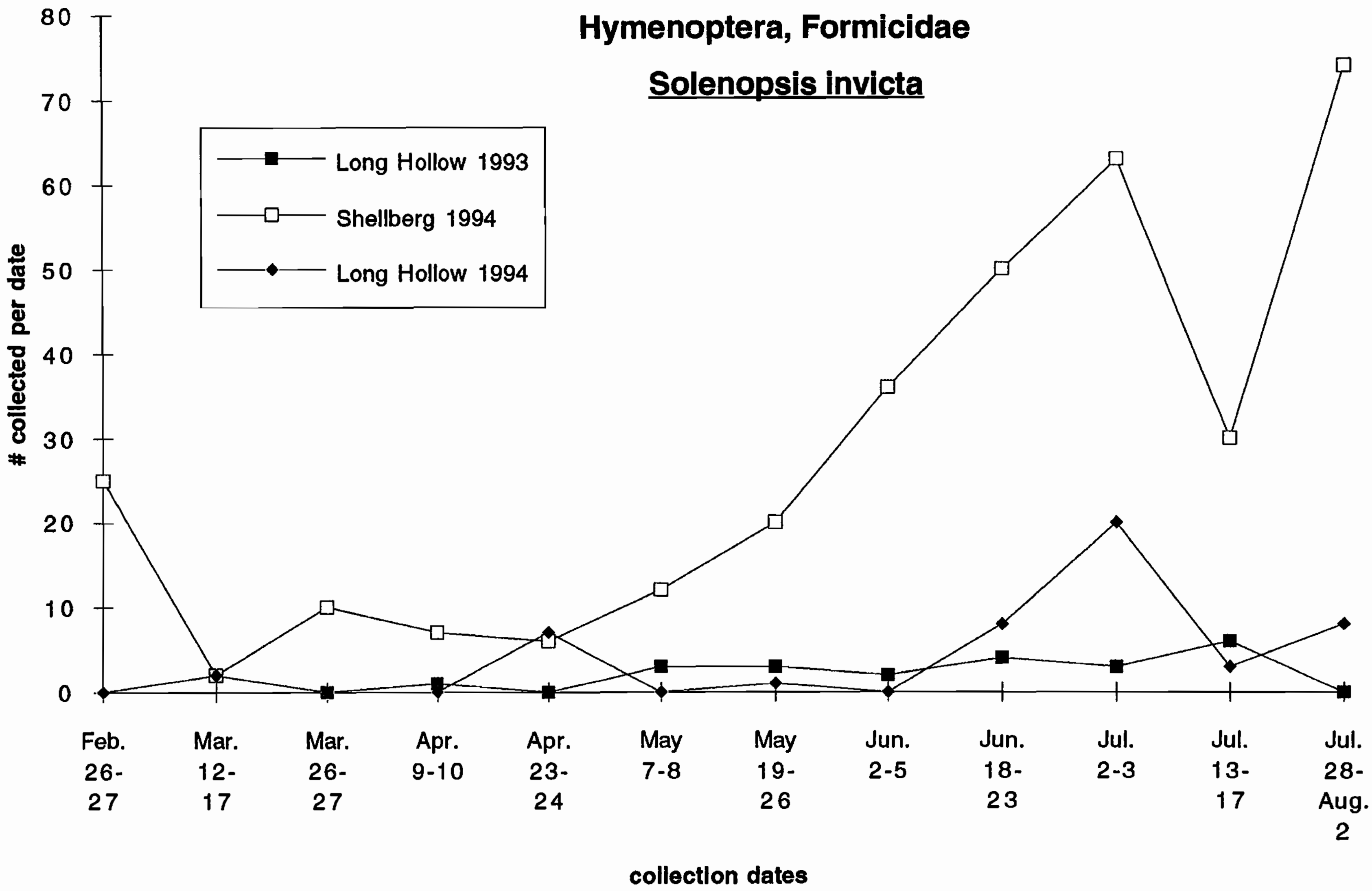

Hymenoptera, Formicidae
Solenopsis invicta
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
collected per date
80
70
60
50
40
30
20
10
0
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Figure 72

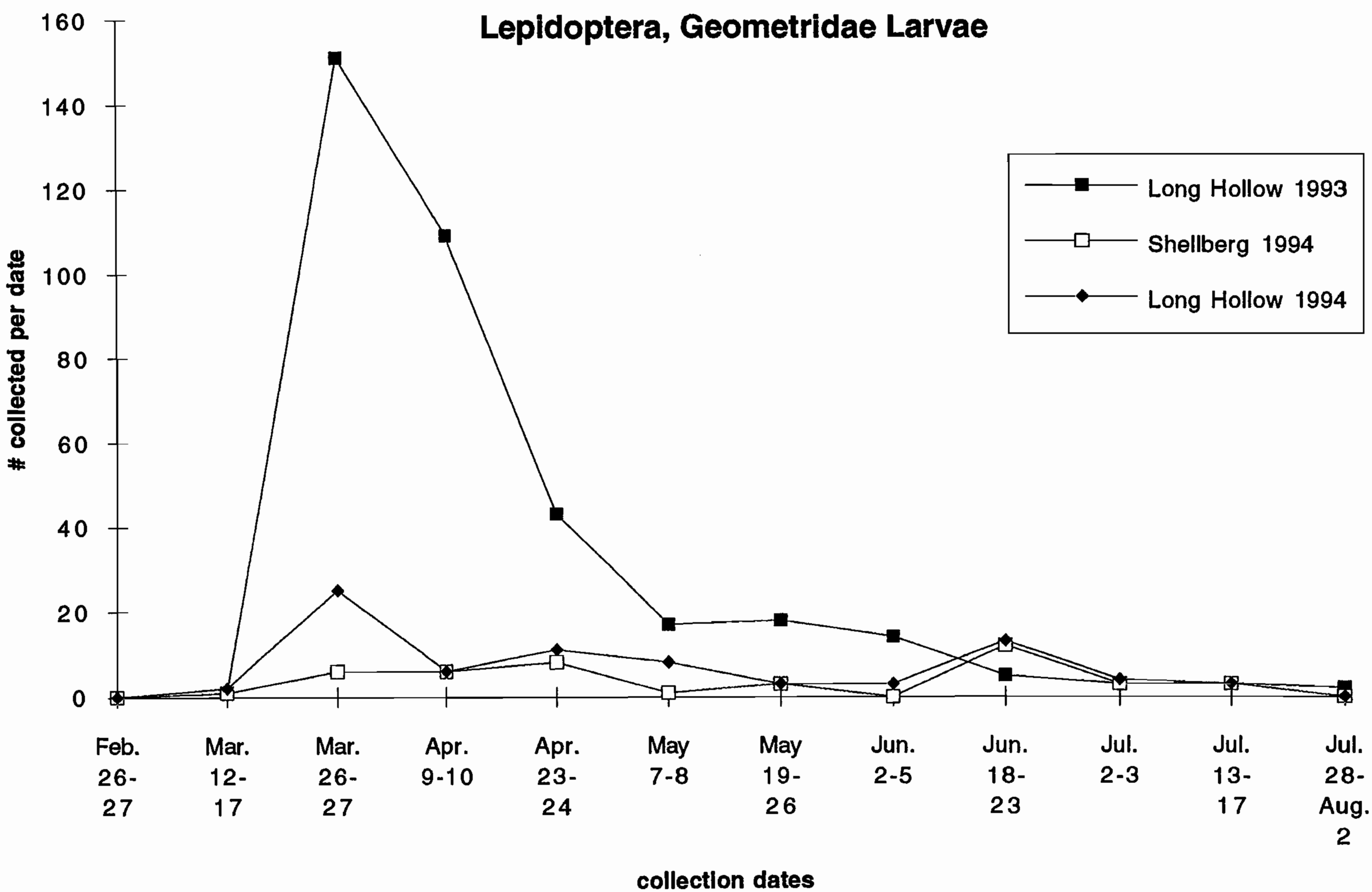

Lepidoptera, Geometridae Larvae
160
140
120
100
80
60
40
20
0
collected per date
Long Hollow 1993
Shellberg 1994
Long Hollow 1994
Feb. 26-27
Mar. 12-17
Mar. 26-27
Apr. 9-10
Apr. 23-24
May 7-8
May 19-26
Jun. 2-5
Jun. 18-23
Jul. 2-3
Jul. 13-17
Jul. 28-Aug. 2
collection dates

Table 1. Collection codes and corresponding collection dates for samples taken in 1993. All collections were from the Long Hollow site in northwestern Travis County.

Collection Code	Collection Date
0	March 13
1	March 26
3	April 10
5	April 23
6	May 8
7	May 26
8	June 5
9	June 23
10	July 3
11	July 17
12	August 2

Table 2. Collection codes and corresponding collection dates and sites for samples taken in 1994.

Collection Code	**Collection Date**	**Collection Site**
13	February 26	Long Hollow
14	February 27	Shellberg
15	March 12, 17	Long Hollow
16	March 17	Shellberg
17	March 26-27	Shellberg
18	March 26	Long Hollow
19	April 9	Long Hollow
20	April 9-10	Shellberg
21	April 23	Long Hollow
22	April 23-24	Shellberg
23	May 7	Long Hollow
24	May 7-8	Shellberg
25	May 19	Long Hollow
26	May 19-20	Shellberg
27	June 2	Long Hollow
28	June 2	Shellberg
29	June 18	Long Hollow
30	June 18-19	Shellberg
31	July 2	Long Hollow
32	July 2-3	Shellberg
33	July 13	Long Hollow
34	July 13-14	Shellberg
35	July 28	Long Hollow
36	July 28-29	Shellberg

Table 3. List of arthropod remains from 22 samples of GCWA gizzards obtained from Warren Pulich.

Arthropod Order	Number of recognizable individuals
Lepidopteran larvae	41
Hymenoptera	27
Homoptera	27
Araneae	27
Coleoptera	26
Isoptera	18
Hemiptera Adults and Nymphs	6
Egg	5
Diptera	2
Other	5