The Capture Rate of Prey in Orb, Sheet, and Tangle Spider Webs

Erin Miller
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Abstract

Arthropods are the most abundant phylum but the order Araneus (spiders) is one of the most abundant species. Spiders have a silk gland called spinnerets, which they use to create their webs; but not all spiders use their silk to make a web. The three main classifications of spider webs are: sheet, orb, and tangle. Since there is a diversity of webs, I wanted to see if the web type has any correlation to the type of prey captured and the number of prey that are captured. Therefore, I hypothesize that the height and web type are the two factors that influence the number of prey caught and the type of prey captured. Small prey, flying prey, crawling prey, other spiders being captured were all statistically significant based on web type. There was a correlation between crawling prey and surface area of webs and a trend between other spiders being captured and surface area of webs. Also, there was a correlation between the surface area of the web and the total amount of prey captured. The height, angle, and surface area were significantly based on the web type. In result, my hypothesis was supported that the height and web type did affect the amount of prey and what type of prey was captured.

Introduction

Arthropods are the most abundant phylum on the earth with about one to one and half million described species. One of the most abundant orders is the Araneus (spiders), with approximately 34,000 different spiders, especially in the temperate forest. Spiders represent a large proportion of arthropod predator biomass (Aitchison and Sutherland 2000). Since spiders are numerous in their population the resources for the spiders are relatively scare since they have to compete for the same resources. As a result, spiders have created their own niche, by using the resources that their bodies produce.

Spiders have silk glands that are called spinnerets (figure 1). The spinnerets are located on the underside of their abdomen (figure 2). The silk is a fibrous protein that is formed inside the spider's body. At first the silk is a liquid that is a little bit thicker than water but once it is excreted from the spinnerets of the spider the silk dries in the air and forms a line that looks like a strand of hair (Kozhukhov 2000).

All spiders are able to produce silk for a particular niche. Some different uses of silk are: draglines are when the spiders hang on a silk string in the middle of the air and it helps them find their way around. Dispersal mechanism or ballooning is when the spider used the wind to blow the silk string to a new location. Then, the mean of escape is when the spider lowers himself on a silk string. The primary function of silk, specific to web weavers, is to create a habitat and a mechanism for capturing prey in the form of a web (Foelix 1996). Since all the spiders have silk glands it does not mean that all spiders use the silk to build webs.

Different spiders weave different types of webs. Three main classifications of webs are orb, tangle, and sheet webs. Orb webs are circular in shape and two-dimensional (figure 3). Orb webs are more advanced and highly intricate. They are generally raised above the ground and oriented to capture flying prey (Kozhnkhov 2000) (figure 4). Tangle webs are three-dimensional which look like a disorganized mess of interwoven silk strands (figure 5). The third web type is the sheet web (figure 6). That is three-dimensional in shape. They can be domed, bowled, or flat in appearance. They consist of two sheets, one to trap the prey and the other to catch the prey as they fall (Rypstra 1983).

Since there such a diversity of web designs, I wanted to look at the three most common web types and see if there is a correlation between the web type (style, size, and orientation) and the amount of different species of prey captured. Also I will address the height of the web from the ground to see if that makes a difference in what type of prey is caught and the amount of prey caught. I hypothesize that the height and web type (style, size, and orientation) does influence what prey and the number of prey that is caught.

Method

Study site

I did my research at the University of Michigan Biological Station in Cheboygan County, Pellston, Michigan. I chose three different sites here at the station and they were: Grapevine Trail, Pine point Trail, which both were very heavily wooded areas, and the main camp, which is an open area that is highly traveled by people.

Procedure

In order to determine the rate of captured prey in spider webs, I collected a total of 60 different webs. To have an equal distribution of each web type, I collected 20 of each web: sheet, orb, and tangle. Each web was observed for two days. On the first day I measured the height, in centimeters, of the web from the ground. Then, I measured the diameter, in centimeters, and used a protractor to figure out the angle of each web. Once I had all the measurements recorded, then I checked to see if there was any prey in the web. If there was, I recorded the size of the prey in millimeters and identified if the prey was crawling, flying or a different spider being captured. I waited approximately 24 hours before collecting data on the second day. During the second observation, I counted the number of prey caught within the last 24 hours and checked to see if they were crawling, flying or a different spider being captured. I also measured each prey in millimeters. I separated the prey measurements into three categories according to size (< 2mm, 2-5mm, and >5mm).

Statistical methods

To test a single variable factor, I used the Wilcoxon test (the Analysis of Variance) to see the difference between the two different means. I used the web type as the single variable in all the tests to see the difference between crawling prey, flying prey, other spiders being captured, and total prey; small (<2mm), medium (2-5mm), and large prey (>5mm); the height from the ground and angle of the web. For each test, I used the Chi Square test to see if there was any statistical significant between the two means. I also used the Spearman's Rho test to analyze the correlation between two different variables. The surface area of the web was used in each test to show the correlation with small, medium, and large prey; crawling prey, flying prey, other spiders being captured, and total prey. To perform each one of these test, I used the JMP version 4.0 (SAS 2000) to find all the statistical analysis.

Results

In the 60 webs that I observed out in the field, I recorded a total of 127 prey (figure 7&8). The small prey had the least captured rate at 23% (n=29), the large prey only had a capture rate of 28% (n=36), and the medium prey had the highest rate of capture in all the webs of 49% (n=62). The web type shows that the small prey was captured more in the orb web (x^2=7.3 df=2 P=. 03) (figure 9). Then both the medium and large prey showed no statistical significant based on web type (medium: x^2 =1.2 df=2 P=. 54; large: x^2 =1.6 df=2 P=. 45) (figure 10 & 11).

There was a significant trend for the crawling prey caught based on the type of web (x^2=5.3 df=2 P=. 072) (figure 12). The web type shows that the flying prey was caught in the orb web over the sheet and tangle webs (x^2= 12 df=2 P= .003) (figure 13). Spiders that are caught in the tangle web by the host spider are statically significant by the web type (x^2= 6 df=2 P= .04) (figure 14). There was no correlation between the crawling prey, flying prey, and spider being captured with the height from the ground (C: R^2=. 0157 P= .9054; F: R2= .1931 P= .1394; S: R^2= .0028 P=. 9830). The correlation between the angle and flying and crawling prey was also not significant (F: R^2= .1488 P=. 3593; C: R^2= .2004 P=. 2150). The correlation between crawling prey and area of the webs was not significant (R^2= .0694 P=. 5980); but there was a correlation between flying prey and area of the webs (R^2= .2947 P=. 0223). Then, there was a trend in correlation between the other spiders and area of the webs (R^2= .2391 P=. 0658).

The total prey by web type has no statistical significant but there was a trend that the prey is based on the web type (x^2= 5 df=2 P=. 09). The orb web has higher mean number of total prey than the sheet and tangle webs (figure 15). There was a correlation between area of the web and the total amount of prey (R^2= .48 P=. 0019); but there was no correlation between the total prey and angle and height (A: R^2= .0571 P=. 7262; H: R^2= .1681 P=. 1992).

There was a statistical significant between the height and the type of web (x^2= 14 df=2 P= .001). The tangle webs are usually perched up in higher vegetation, while the sheet webs are in vegetation lower to the ground (figure 16). The angle was statistically significant based on the web type (x^2= 16 df=1 P=. 0001). It shows that the orb web has more of an angle in respect to the horizontal line (figure 17). Then the surface area of each web type showed significant also (x^2= 8 df=2 P=. 02) (figure 18).

Discussion

The results of the height of the web and web type did support my hypothesis. The type of prey that a spider will capture in the air depends on various factors such as the web design, the material used and placement or location of the web (Sherman 1994). In response to height, the web types were weaved from a certain distance from the ground. The tangle webs were found in higher vegetation, while the sheet webs were located near the ground level vegetation. The orb webs were weaved higher than the sheet webs but not as high as the tangled webs. The web type did influence what kind of prey the spider captured and how much prey the spider caught within a 24-hour time span.

The surface area and the angle also helped in the rate of capture. The bigger the web the more prey the spider was able to catch. The orb web was angled more than the sheet and tangle web; therefore there was a strong correlation that those webs were able to capture more prey. Spiders adjust their web angle according to the prey capture rate and prey type because the construction of a silk web is highly costly (Nakata 1999).

For future studies, I would research if the rate of capture prey were correlated to the web relocation and the investment in web threads. Kensuke Nakata performed this study but only with an orb-web spider. Therefore the study could be based on the sheet and tangled webs and see if there is any difference between the three types of web weavers and their investment with silk in web building.

There was a research based on orb weaving spiders to see if the spiders had a specific behavior response to spatial variation (Olive 1982). Another study was on the reasons why the orb web weavers relocate and make a new web during the nighttime and to see if it was correlated to the spiders foraging strategies (Sherman 1994). In the previous studies, they all have been related to the orb web or their weavers and I have not found any based on the tangle or sheet webs. So for the future we could do more research on the tangle and sheet web weavers.

As previously stated, spiders represent a large proportion of the arthropod phylum but yet very little is published about them. There is very little knowledge about spiders that more research needs to be done, so we can understand the spiders better and translated the information to the public. Spiders are a key member of the ecosystem and an important link in the food chain. Therefore, productive research to better understand their ecological contribution is not only important but also necessary to understanding the complete structure of the food chain and predator-prey relationships.

Acknowledgement

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Figure 1. The silk gland and spinneret of a spider

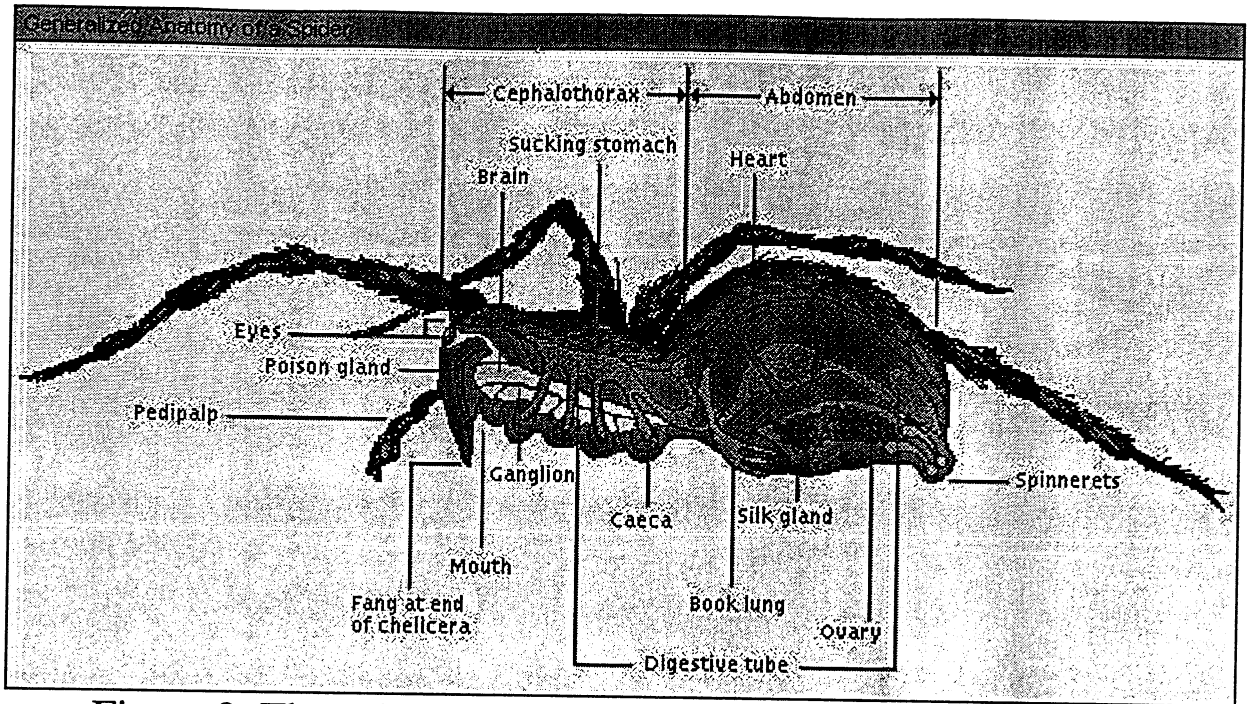

Figure 2. The spinnerets shown beneath the spider's abdomen

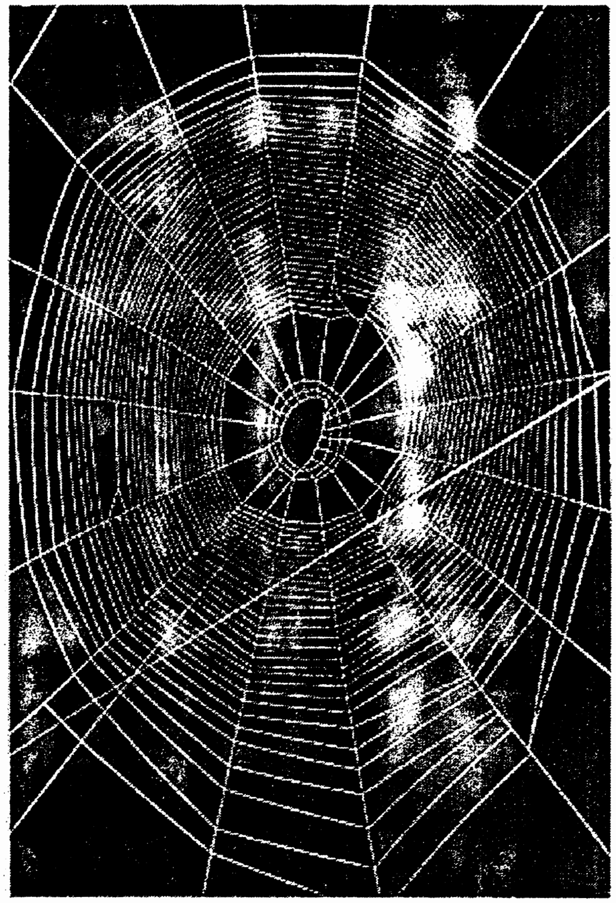

Figure 3. An orb web

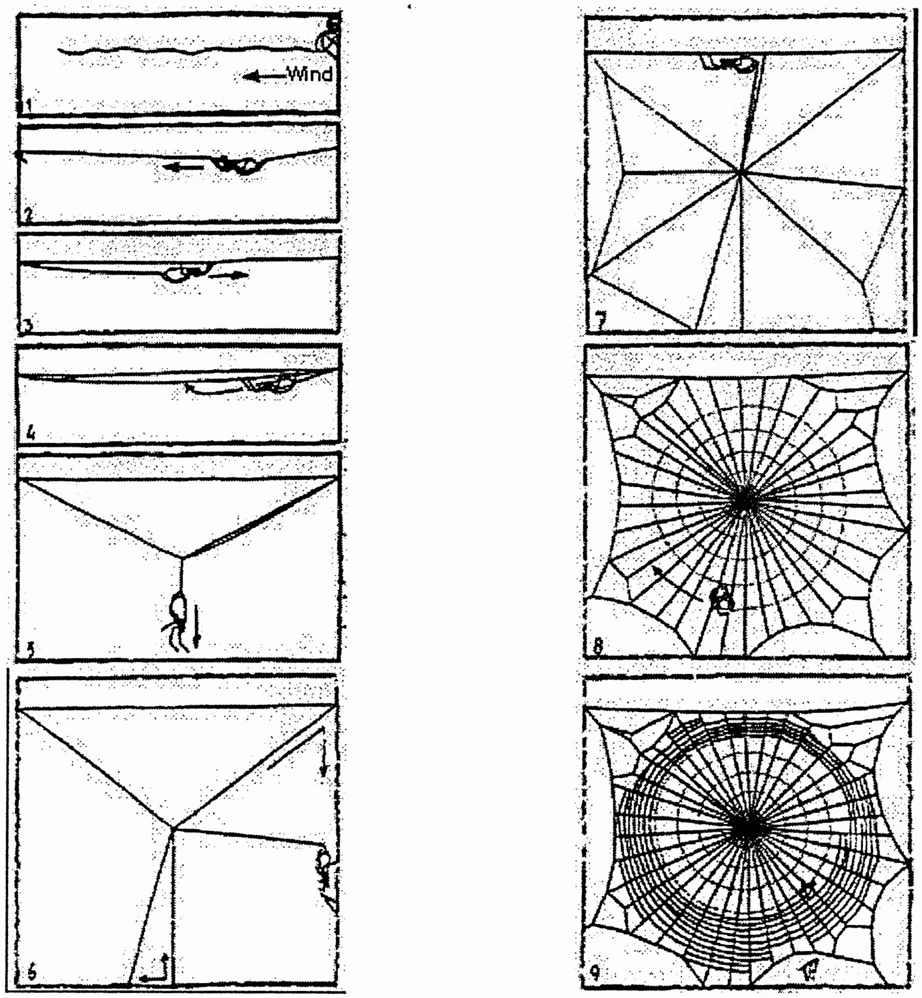

Figure 4. The development of an orb web

Figure 5. A tangle web

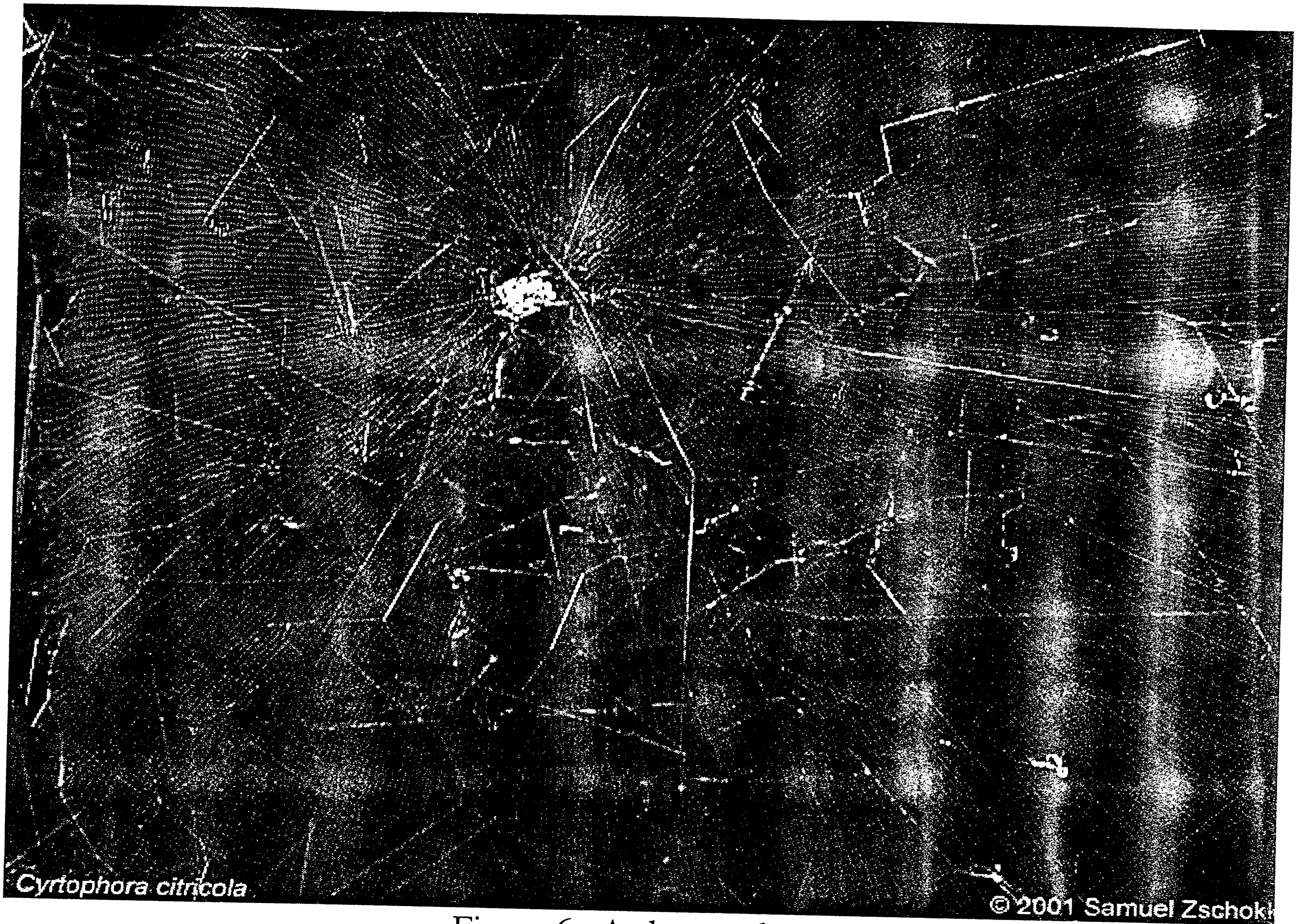

Figure 6. A sheet web

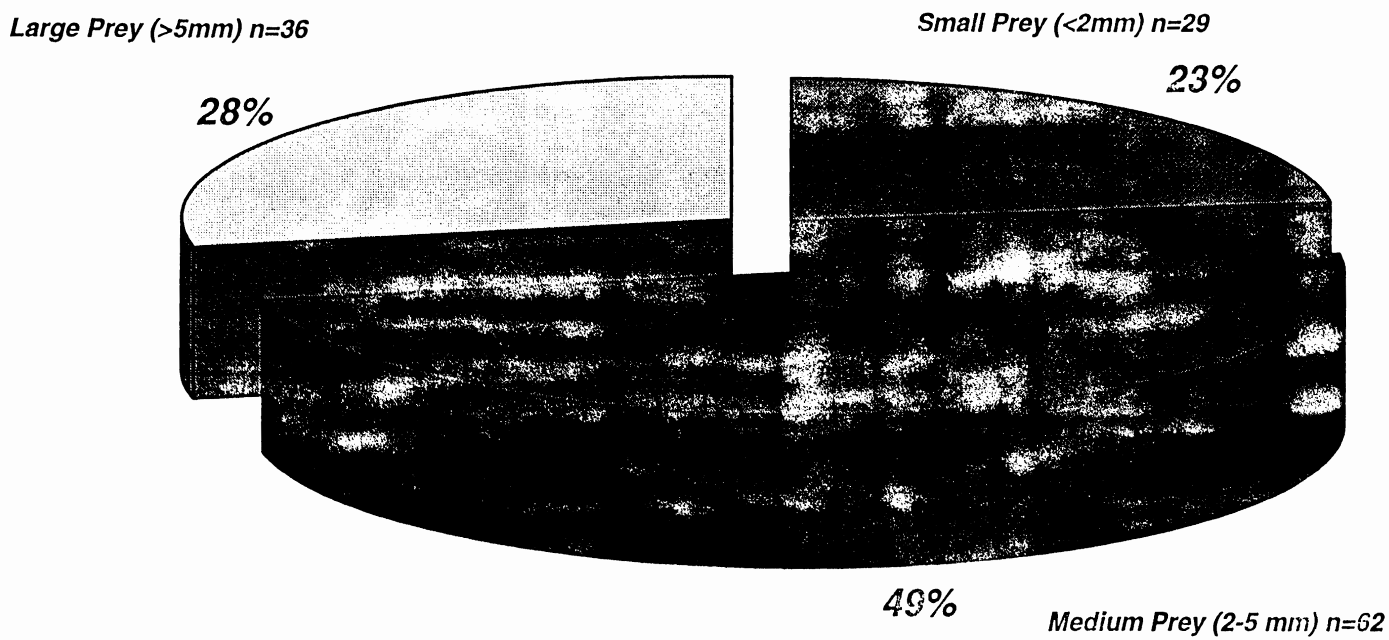

Figure 7. Total quantities of the three prey size categories found in all webs. There was a total of 127 prey items found.

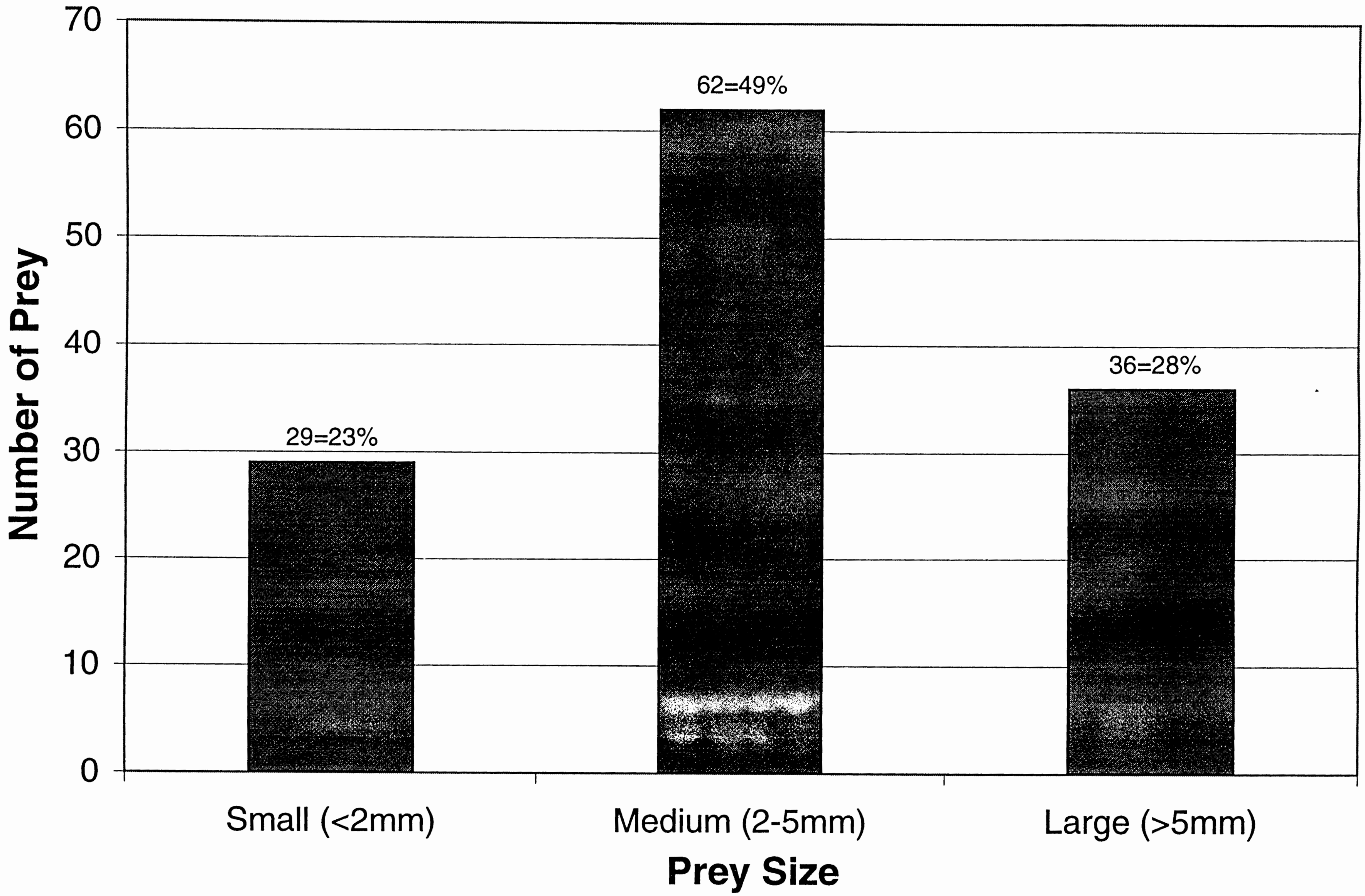

Figure 8. Total quantities of the three prey size categories found in all webs. There was a total of 127 prey items found.

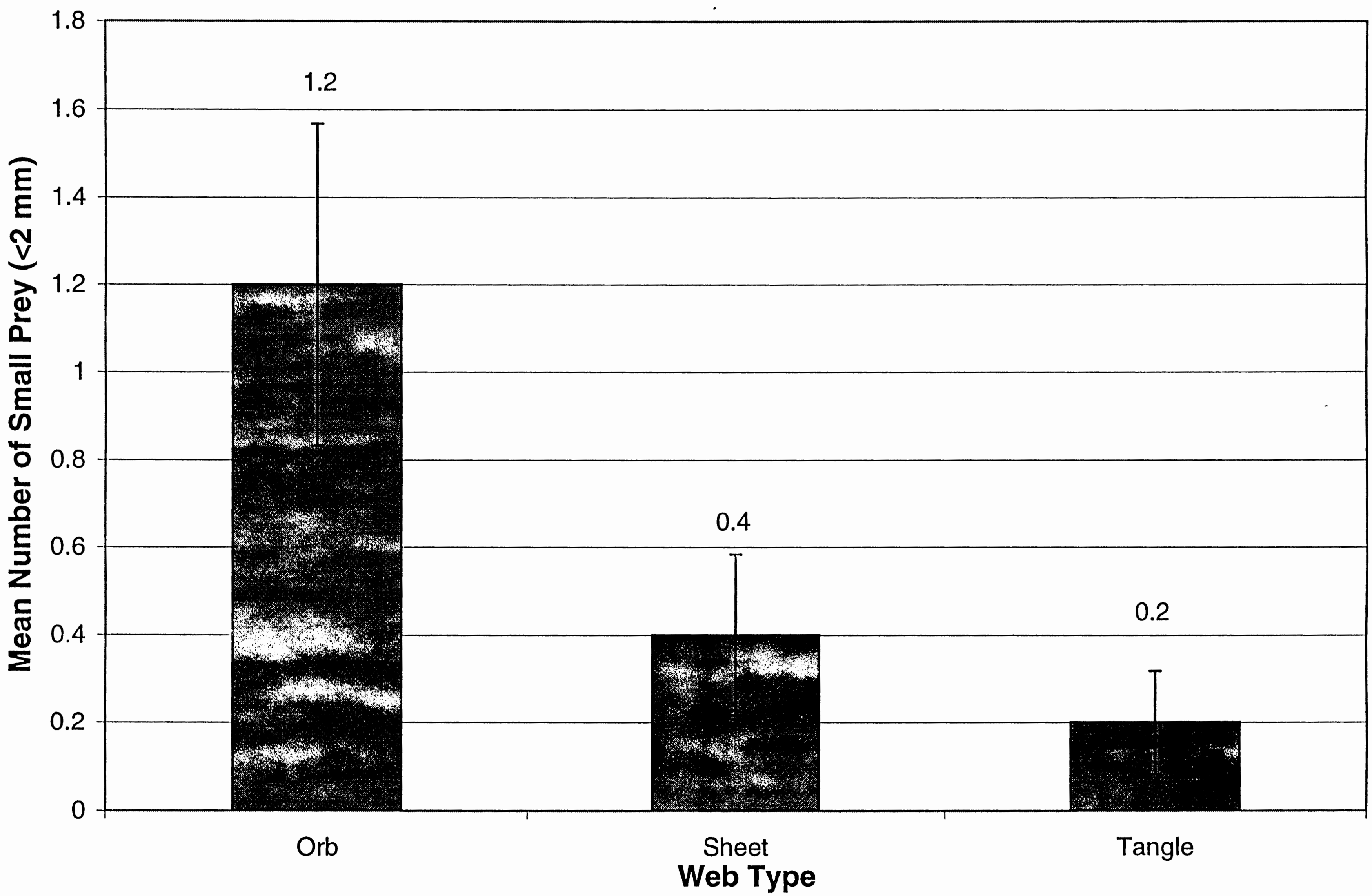

Figure 9. Mean number of small prey (<2cm) per web (± SE) based on web type. (n=60, X =7.3215, df=2, p=0.0257)

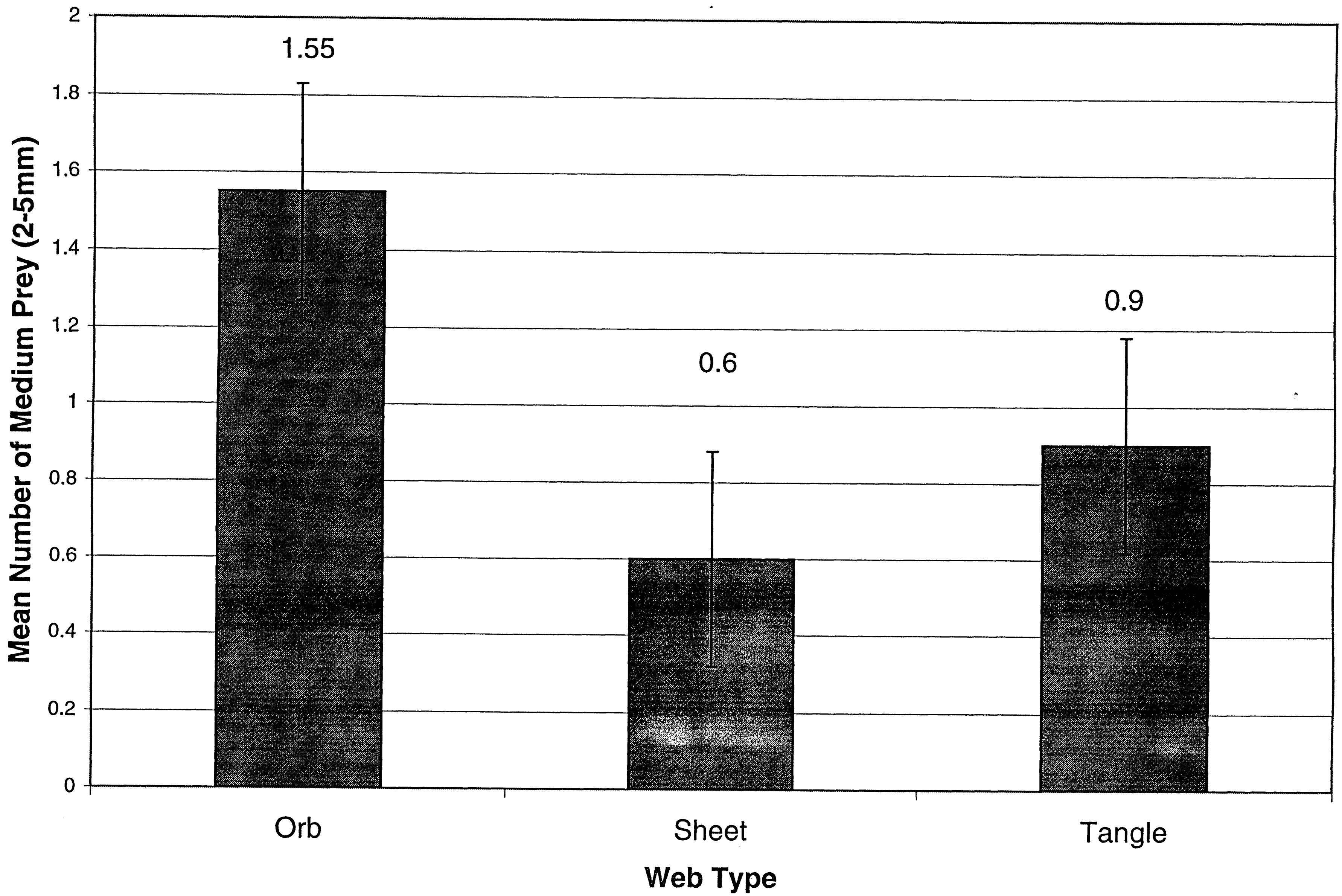

Figure 10. Mean number of medium prey (2-5mm) per web (± SE) based on web type. (χ^2= 1.2 df= 2 P= .54)

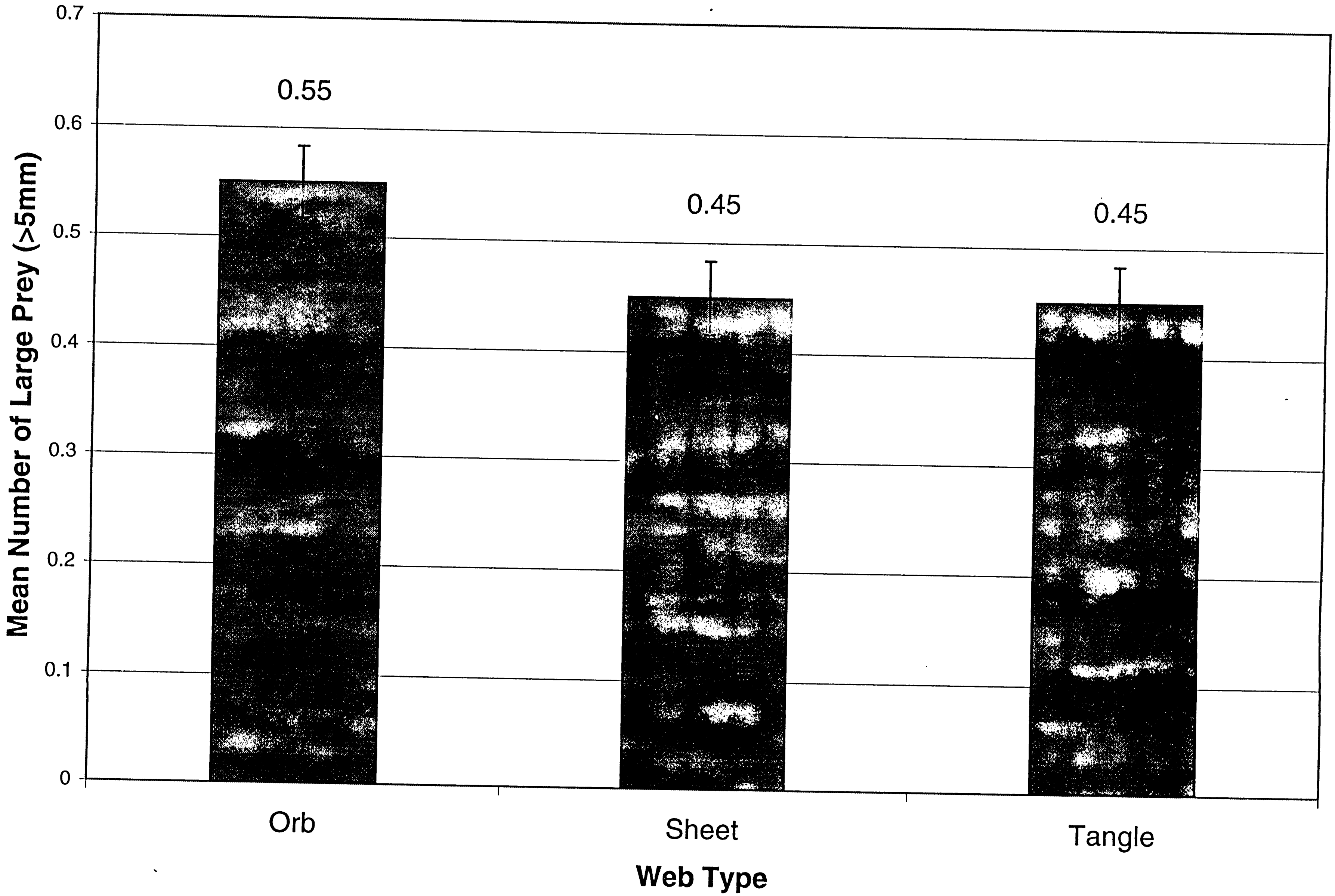

Figure 11. Mean number of large prey (>5mm) per web (± SE) based on web type. (χ^2= 1.6 df: 2 P=.45)

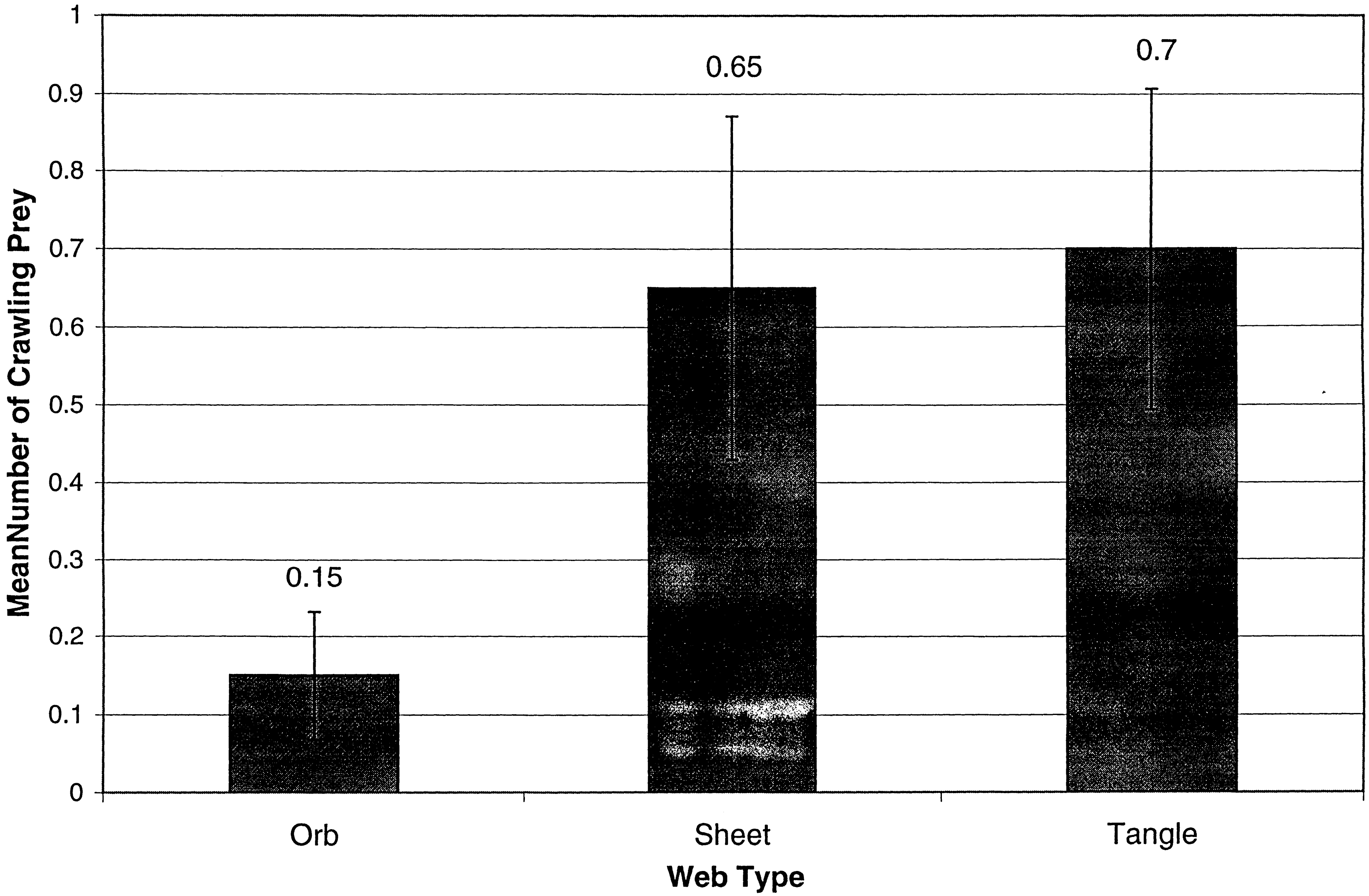

Figure 12. Mean Number of crawling prey per web (+SE) based on web type. (n=60, X =5.2674, df=2, p=0.0718)

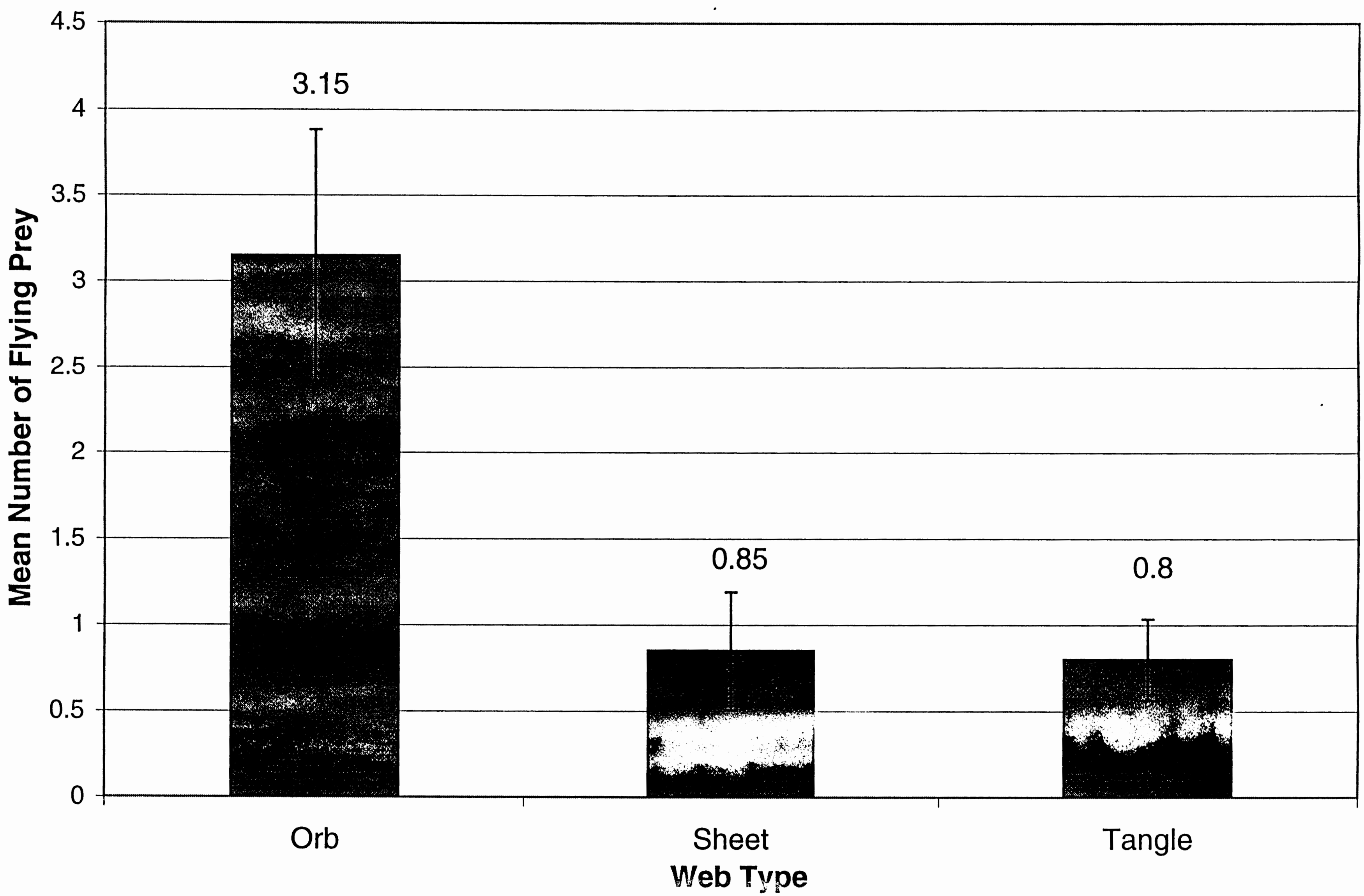

Figure 13. Mean number of flying prey per web (± SE) based on web type. (n=60, X =11.8157, df=2, p=0.0027)

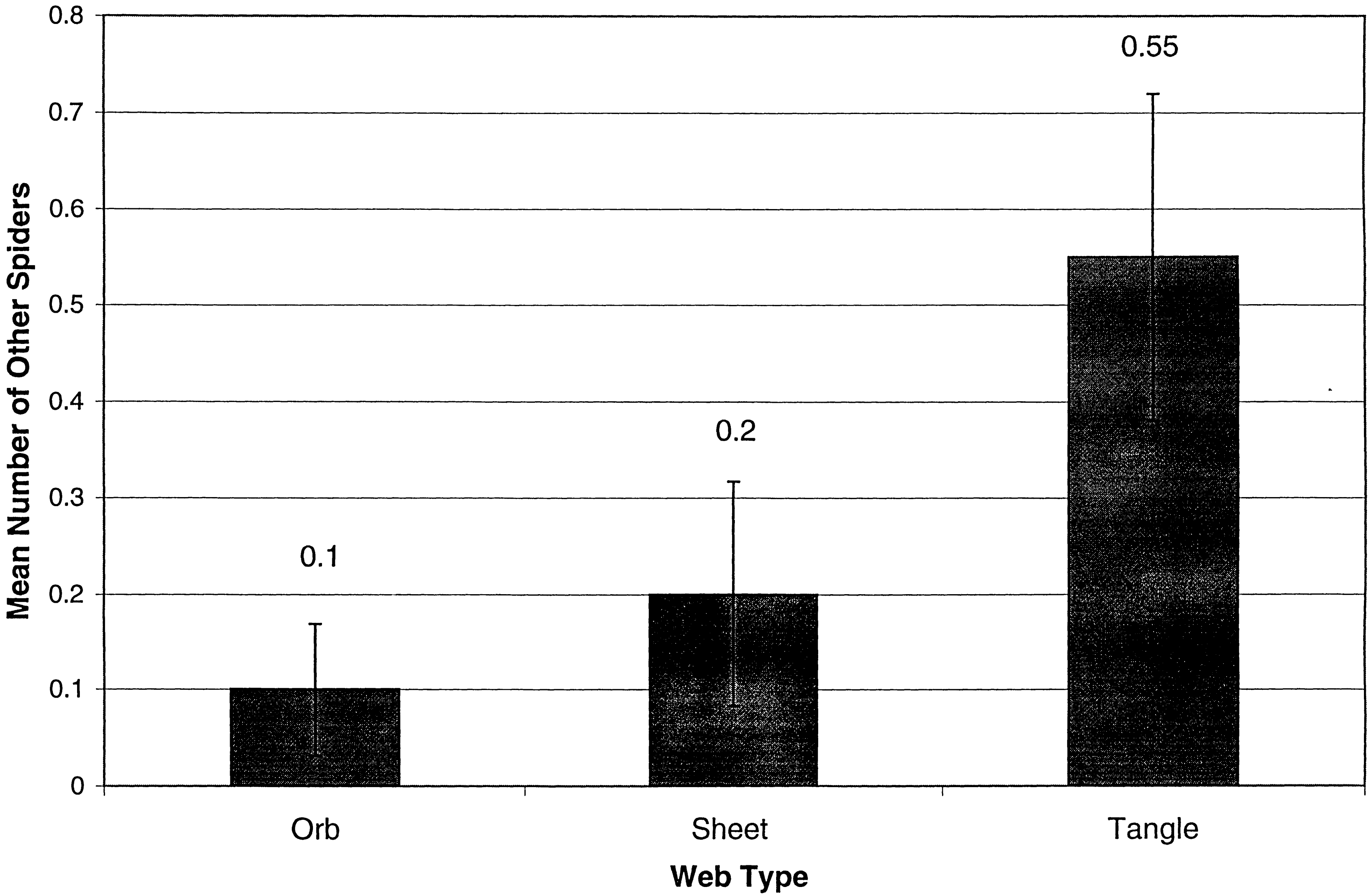

Figure 14. Mean Number of other spiders (as prey) per web ($\pm$SE) based on web type. (n=60, X =6.3305, df=2, p=0.0422)

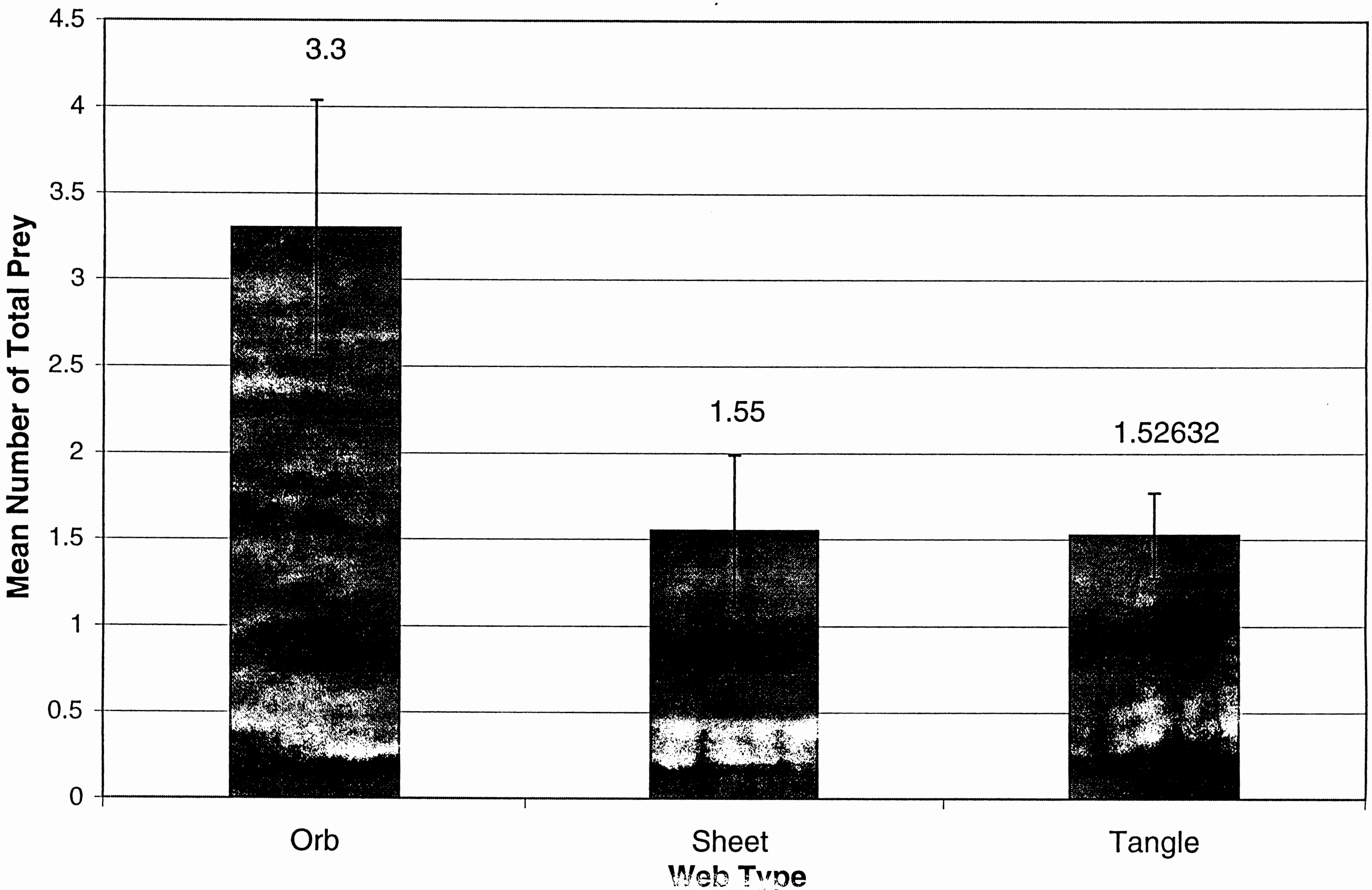

Figure 15. Mean number of total prey per web (± SE) based on web type. (n=60, X =4.[illegible]277, df=2, p=0.0851)

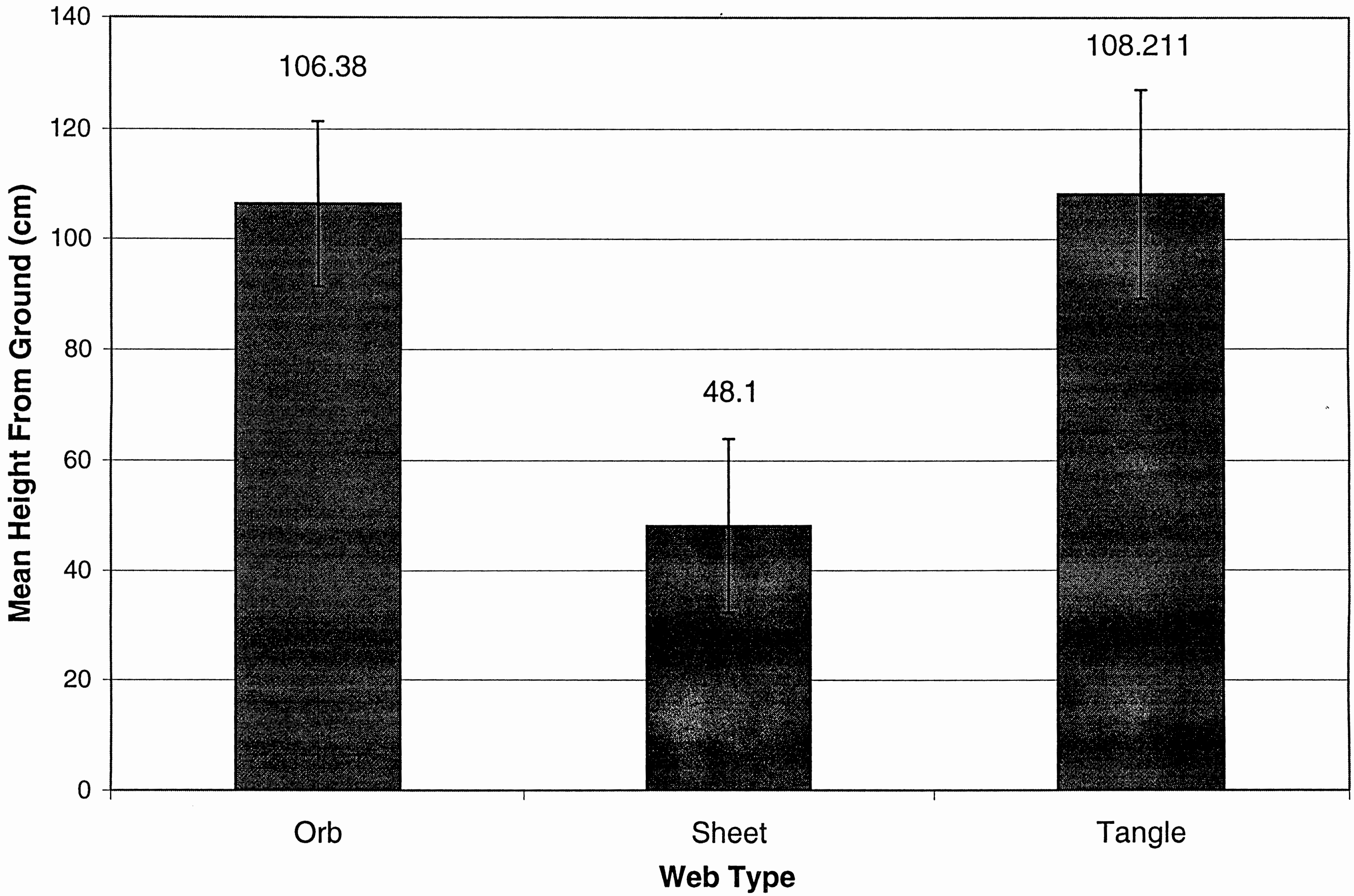

Figure 16. Mean Height of the web (in cm) from the ground (+SE) based on web type. (n=60, X =13.8295, df=2, p=0.0010)

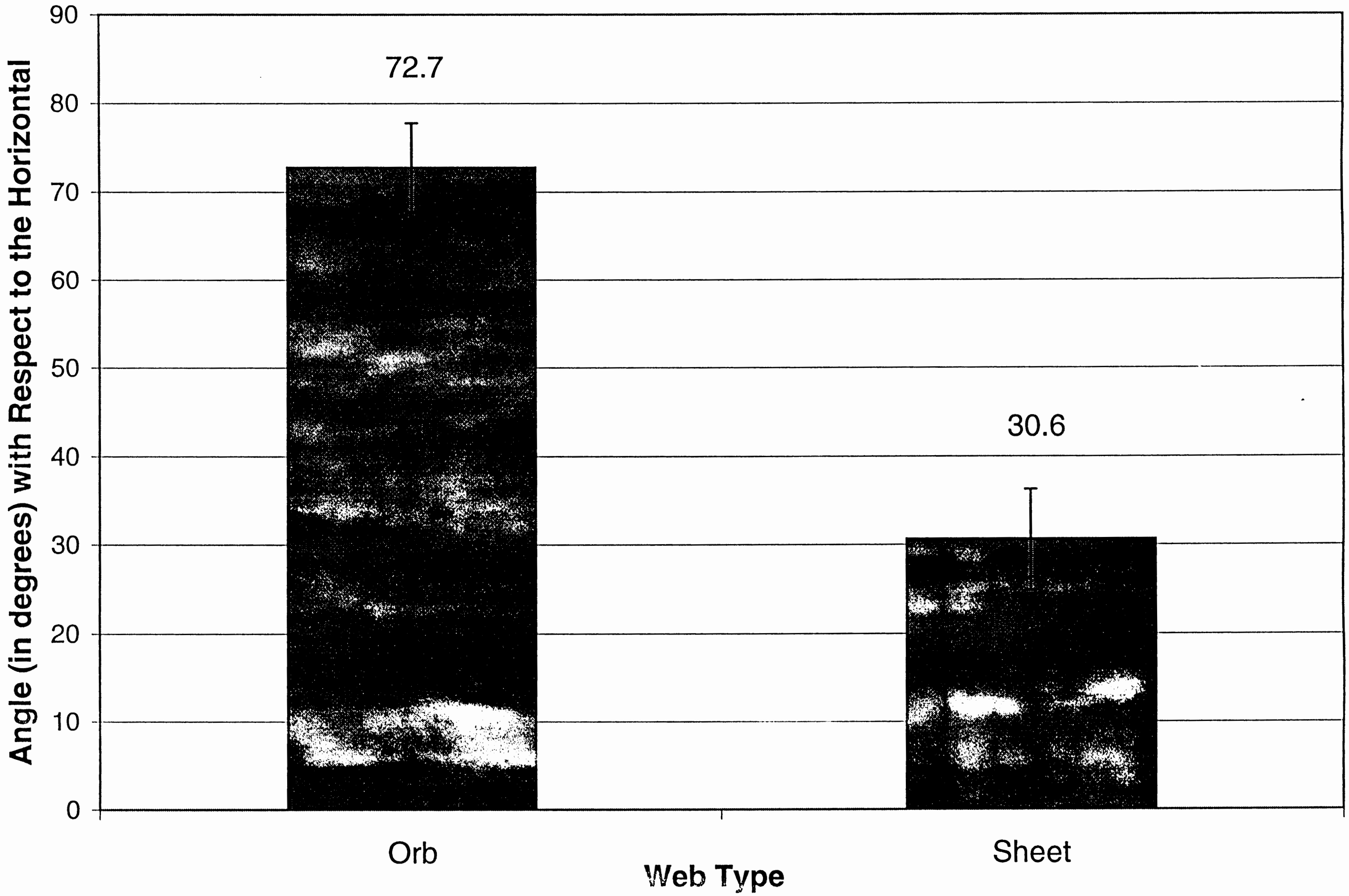

Figure 17. Mean angle of the web (in degrees) with respect to the horizontal by web type. ($n=60$, X $=16.062$, $df=1$, $p<0.001$)

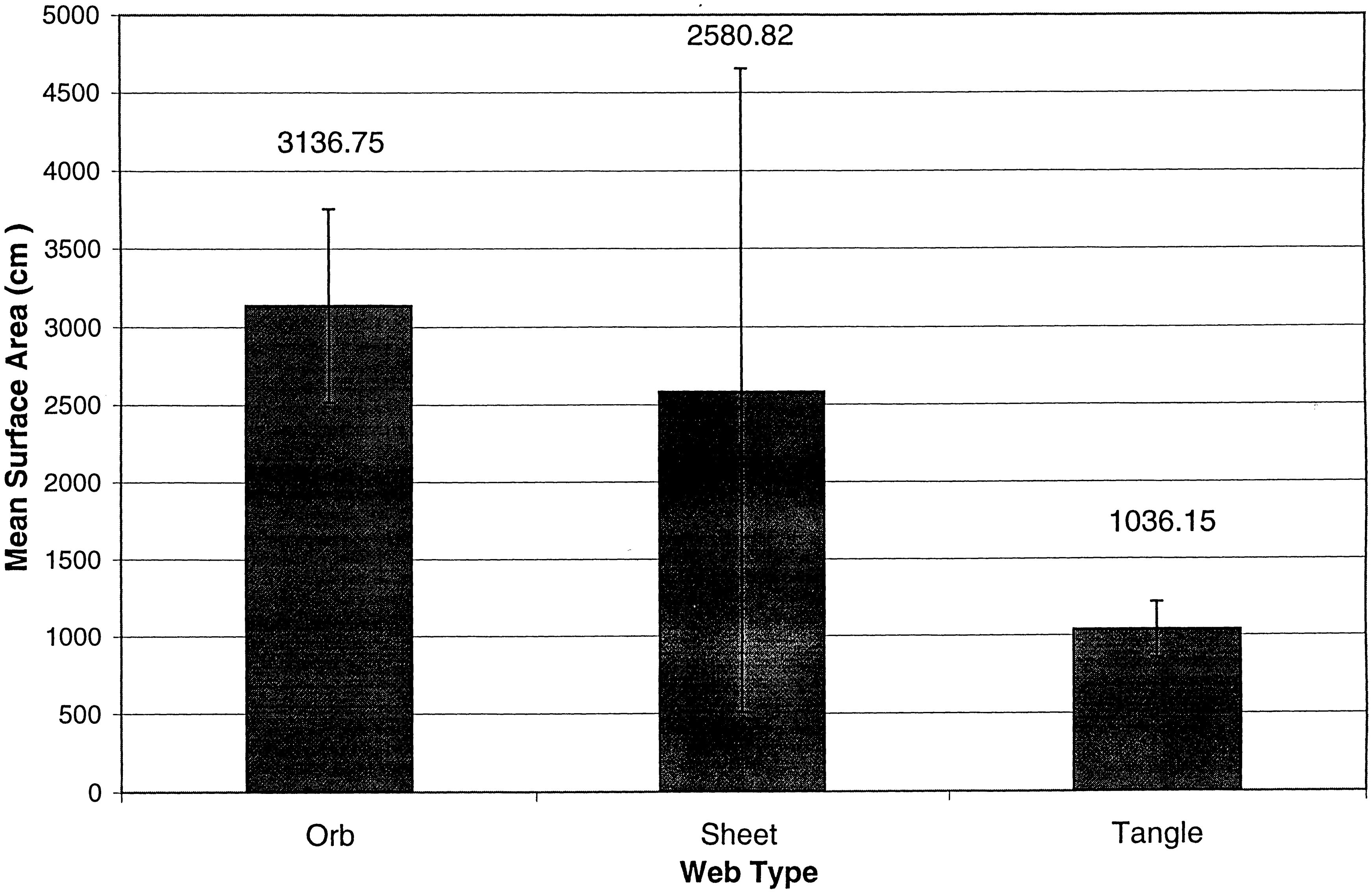

Figure 18. Mean surface area (in cm) of web(+SE) based on web type. (n=60, X =7.9731, df=2, p=0.0186)