THE EFFECTS OF *Alcohol on Spiders*

What Happens to Web Construction After Spiders Consume Alcohol?

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Not all spiders spin webs; the spiders that do, spin them in a wide variety of shapes and sizes. As a matter of fact, some species of spiders have been described by their unique web design, and the spiders themselves have never been captured (Dr. Joseph Culin, personal communication, 2003).

A German scientist, Peter Witt, studied the web spinning habits of spiders. This research was made difficult by the fact that the spiders Witt observed did not begin spinning webs until long after dark, and it was not unusual for the observations to run into the early hours of the morning. Witt wondered if feeding drugs to the spiders would cause them to spin their webs at a different time of day, making the observations easier (Dr. Gary Mullen, personal communication, 2003).

Witt (1956) fed spiders drug-dosed flies. Mescaline sulfate caused the spiders to spin webs with a wider gap at the top. Hashish not only caused the spiders to leave large spaces, but prevented them from even finishing the webs. When the spiders were fed flies dosed with LSD, they spun the symmetrical dragline threads, but produced few sections of sticky spiral. Caffeine caused the spiders to spin webs with no symmetry. Witt and his colleagues also studied the effects of diazepam (valium), phenobarbital, and caffeine (Witt, Reed & Peakall, 1968).

Mullen (1969) investigated the morphology and histology of the silk glands in *Araneus sericatus* CL. in an effort to dismiss earlier unjustified conclusions with respect to the role of the various glands in spider web production. There are eight different types of silk glands. He concluded that the ampullate glands produce the dragline frame threads and the dry base thread of the sticky spiral portion of the orb web; the pyriform glands form the attachment discs and the accessory frame threads.

In 1995 NASA proposed using spiders as toxicity testers. Scientists sprayed spider webs with a variety of drugs including chloral hydrate (Anonymous, 1995). Because spider webs resemble crystal lattices, the toxicologists used statistical crystallography to gauge the toxicity of the substances. The NASA scientists analyzed the number of completed cells, radii, and other geometric structures of the web. They determined that as toxicity increased, the deformation of the web increased quantifiably (Connor, 1995).

In humans caffeine causes stimulation of the central nervous system, increased blood pressure and pulse rate, restlessness, and insomnia (Harrison, 1997). Spiders that have been dosed with caffeine produce a web that has no symmetry or other evidence of a traditional web plan (Witt, 1956). Marijuana causes sedation, euphoria, and altered mental processes in humans, along with distorted perception, anxiety, and panic (Harrison, 1997). In spiders, it yields distorted webs (Witt, 1956). Psychedelics such as LSD cause alteration of mental processes, aggressive behavior, distorted perceptions, and confusion in humans (Harrison, 1997). LSD causes symmetrical but totally different webs in the spiders that Witt (1956) studied. Alcohol (beer, wine, and hard liquor) acts as a depressant in humans, also resulting in relaxation, lowered inhibitions, loss of body control, and reduced muscular coordination (Harrison, 1997). The effect of alcohol on the spinning abilities of orb weaver spiders is not discussed in the literature.

In general orb weaver spiders are found spinning webs after dark, but prefer well-lighted areas that attract insects upon which the spiders feed (Levi, 2002). Adult orb weaver spiders are found from late summer through the fall of the year. Small orb weaver spiders feed on flies and moths. Golden orb weavers eat large beetles, small grasshoppers, caterpillars, or anything half their size. They don't eat much. Orb weaver spiders in captivity should be fed once per week unless they are recycling their webs. Spiders that are recycling webs should be fed less. Spiders do best at room temperature, with 12 hours of light and 12 hours of darkness. In captivity, the webs must be misted to keep the spiders hydrated (Dr. Gary Mullen, personal communication, 2003).

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In this experiment spiders are provided with 40% ethanol (ETOH) in order to determine the effects of alcohol on the web-spinning ability of orb weaver spiders. It is hypothesized that alcohol has a deleterious effect on the number of radii, number of cells, and area of cells in the webs of orb weaving spiders.

Methods & Materials

After unsuccessful attempts to get spiders to spin webs in captivity, it was decided to use spiders in the wild at the following locations: Reynolds Plantation; FDR State Park near Pine Mountain, Georgia; Lee Road; and Beacon Street. Unusually high levels of rainfall in the summer and fall of 2003 fostered an abundance of spiders. When a spider had completely spun a web, the web was sprayed with a light mist of ice cold water. (Spraying the web with water did not cause the spider to respond.) The spider web was then photographed using a Sony Mavica CD 300 digital camera. A strong spotlight was used to highlight the web for photographic purposes. If the background made the web difficult to photograph, a black background was erected directly behind the web. The diameter of the web was recorded. The web was allowed to dry.

A second mister was used to mist the web with the 40% ETOH (vodka). A house fly was then introduced into the web. When the spider began to wrap the fly with silk, the spider absorbed the alcohol into its system. The new web was then destroyed except for one to two support filaments. The spider was ignored for 30 minutes to two hours while it spun another web. The new web was misted with water and photographed. The diameter of the web was recorded. Photographs were taken of the webs spun under the influence of the vodka. Several attempts were made to videotape the spiders on the webs, but the bright light of the video camera caused the spider to retreat or stop spinning.

Following the "after" photographs, the spider was collected and placed in very hot water to kill it. The spider was then placed in 40% ETOH for 24 hours. After 24 hours, the 40% ETOH was replaced with 70% ETOH. The preserved spiders were placed in glass vials with neoprene stoppers. A label was placed inside of each vial indicating the location and date of capture. Preliminary identifications were made utilizing a Zeiss dissection microscope and the *Golden Book of Spiders* (Levi, 2002). Spiders were videotaped and digitally photographed to enhance taxonomic details. After all spiders had been collected, they were taken to Dr. Gary Mullen (Department of Entomology, College of Agriculture, Auburn University) for taxonomic assistance and verification.

"Before" and "after" photographs of each spider were printed using a HP Color Laser 5500 printer. The following parameters were determined for each web:

- number of support strands
- number of cells
- area of cells (average of 30 cells)

The number of large holes in each web was counted. The measurements were made from the photographs using metric rulers. The diameter of the actual web and the diameter of the web in the photograph were set up as a ratio to determine a conversion factor to ensure that the measurements, before and after, were on an identical scale. Web area was determined by superimposing the web outline on graph paper using Adobe® Photoshop® 7.0.

The following data were analyzed: number of rays before and after alcohol was consumed, number of cells before and after alcohol was consumed, and average cell area before and after alcohol was consumed. The cumulative data were analyzed by a two-sample Z-test, and the data from the individual spider species was analyzed by a two-sample *t*-test. The statistics program from the TI 83 plus silver edition was utilized for all computer analyses. Raphael Simmons, (statistics teacher at Carver High School, Columbus, GA) provided assistance with statistical analysis.

Results

39 individual spiders were studied and grouped taxonomically, by sex, and by location:

Female .... *Neoscona* sp.

Female .... Araneidae

Female .... *Gasteracantha elipsoides*

Male .... Araneidae

Male .... *Tetragnatha* sp.

(No key for males of this species) . . . Araneidae, FDR State Park

(No key for males of this species) . . . Araneidae, Lee Road

Photographs of the spider webs taken before and after ingestion of alcohol may be found in Figures 1-4.

After the data were collected and compiled in tables, they were analyzed statistically. A two-sample Z-test was used to analyze the number of rays, number of cells, and total area of the cells for the 39 specimens. The statistical analysis yielded the following results:

Number of Rays

H_o: $\mu_1 \leq \mu_2$ H_a: $\mu_1 > \mu_2$

$n = 39$

Number of rays before vodka (mean $\pm$ SD) = 36.19 ± 11.42

Number of rays after vodka (mean $\pm$ SD) = 18.74 ± 8.54

$p = 7.044 \times 10^{-5}$

reject H_o, accept H_a

The number of rays produced by the orb weaver spiders before alcohol is consumed is significantly greater than the number of rays produced after alcohol is consumed at the 0.01 confidence level.

Figure 1. Webs spun before and after imbibing alcohol for *Neoscoma* sp.

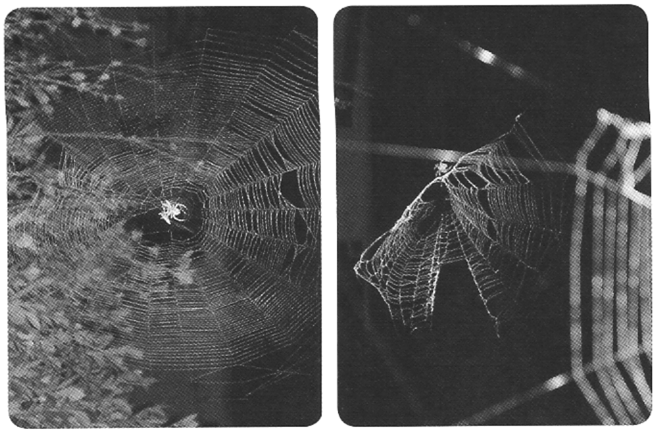
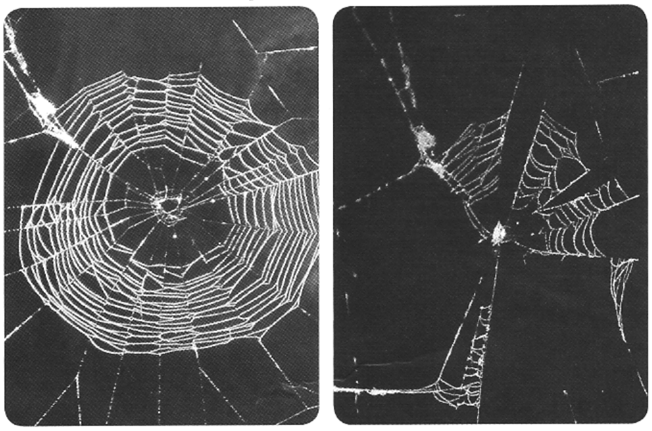


Figure 2. Webs spun before and after imbibing alcohol for *Gasteracantha elipsoides*.



Number of Cells

$H_{o:}\ \mu_1 \leq \mu_2$ H_a: $\mu_1 > \mu_2$

n = 39

Number of cells before vodka (mean $\pm$ SD) = 723.33 $\pm$ 421.77

Number of cells after vodka (mean $\pm$ SD) = 279.98 $\pm$ 206.18

$p = 1.727 \times 10^{-11}$

reject $H_{o,}$ accept H_a

The number of cells produced by the orb weaver spiders before alcohol is consumed is significantly greater than the number of cells produced after alcohol is consumed at the 0.01 confidence level.

Average Cell Area

$H_{o:}\ \mu_1 \leq \mu_2$ H_a: $\mu_1 > \mu_2$

n= 39

Area of cells before vodka (mean $\pm$ SD) = 95.84 $\pm$ 56.93mm^2

Area of cells after vodka (mean $\pm$ SD) = 140.91 $\pm$ 63.90mm^2

Figure 3. Webs spun before and after imbibing alcohol for *Tetragnatha* sp.

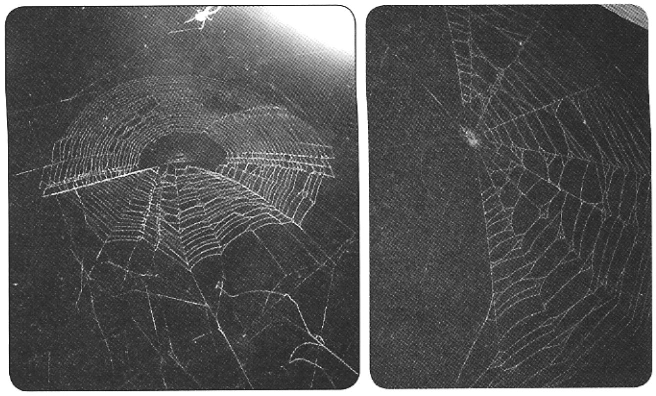


Figure 4. Webs spun before and after imbibing alcohol for female Araneidae.

$p= 9.0257 \times 10^{-4}$

accept $H_{o:}$ reject H_a

The average cell area produced by the orb weaver spiders after alcohol is consumed is larger than the average cell area before the alcohol is consumed at the 0.01 confidence level.

In addition to performing the two-sample Z-test on the total number of webs, a two-sample *t*-test was performed on the webs of each species of spider. The statistical analyses for the number of rays for all spiders are found in Table 1. The statistical analyses for the number of cells for all spiders are found in Table 2. The statistical analyses for the total cell area for all spiders are found in Table 3.

In addition to the numerical data, there were additional behavioral observations. After the spiders had consumed the vodka, the spinning of the second web appeared to be completed more quickly, and the movements of the spiders were quite jerky. Additionally, after spinning portions of the web, the spiders consistently ripped large holes in the webs. Table 4 compares the number of these large holes before and after alcohol treatment. The spiders appeared almost "angry" while spinning webs after consuming alcohol.

Table 1. Results of two-sample *t*-test of spiders by group for number of rays.

Spider	Hypothesis	Mean ± Standard Deviation Before	Mean ± Standard Deviation After	P	Analysis
Neoscona sp n = 14	$H_o: \mu 1 \leq \mu 2$ $Ha: \mu 1 > \mu 2$	26.57 ± 6.33	20.07 ± 6.58	0.008	reject Ho; accept Ha 0.01 confidence level
Female Araneidae n = 5	$H_o: \mu 1 \leq \mu 2$ $Ha: \mu 1 > \mu 2$	51.40 ± 8.54	32.00 ± 9.44	0.008	reject Ho; accept Ha 0.01 confidence level
Gasteracantha elipsoides n = 7	$H_o: \mu 1 \leq \mu 2$ $Ha: \mu 1 > \mu 2$	21.43 ± 4.06	15.43 ± 2.96	0.007	reject Ho; accept Ha 0.01 confidence level
Male Araneidae n = 6	$H_o: \mu 1 \leq \mu 2$ $Ha: \mu 1 > \mu 2$	22.33 ± 2.56	13.67 ± 4.60	0.003	reject Ho; accept Ha 0.01 confidence level
Tetragnatha sp. n = 2	$H_o: \mu 1 \leq \mu 2$ $Ha: \mu 1 > \mu 2$	19.50 ± 0.50	13.00 ± 0.00	0.024	reject Ho; accept Ha 0.05 confidence level
Male Araneidae n = 3	$H_o: \mu 1 \leq \mu 2$ $Ha: \mu 1 > \mu 2$	22.10 ± 3.091	18.33 ± 8.73	0.076	reject Ho; accept Ha 0.10 confidence level
Male Araneidae n = 2	$H_o: \mu 1 \leq \mu 2$ $Ha: \mu 1 > \mu 2$	11.50 ± 0.5	9.50 ± 0.5	0.037	reject Ho; accept Ha 0.10 confidence level

Table 2. Results of two-sample *t*-test of individual spiders for number of cells.

Spider	Hypothesis	Mean ± Standard Deviation Before	Mean ± Standard Deviation After	P	Analysis
Neoscona sp n = 14	$H_o: \mu 1 \leq \mu 2$ $Ha: \mu 1 > \mu 2$	381.349	212.730	2.25×10^{-5}	reject Ho; accept Ha 0.01 confidence level
Female Araneidae n = 5	$H_o: \mu 1 \leq \mu 2$ $Ha: \mu 1 > \mu 2$	258.662	189.869	0.001	reject Ho; accept Ha 0.01 confidence level
Gasteracantha elipsoides n=7	$H_o: \mu 1 \leq \mu 2$ $Ha: \mu 1 > \mu 2$	129.391	55.854	0.002	reject Ho; accept Ha 0.01 confidence level
Male Araneidae n = 6	$H_o: \mu 1 \leq \mu 2$ $Ha: \mu 1 > \mu 2$	149.561	142.047	0.002	reject Ho; accept Ha 0.01 confidence level
Tetragnatha sp. n = 2	$H_o: \mu 1 \leq \mu 2$ $Ha: \mu 1 > \mu 2$	38.00	37.50	0.057	reject Ho; accept Ha 0.10 confidence level
Male Araneidae n = 3	$H_o: \mu 1 \leq \mu 2$ $Ha: \mu 1 > \mu 2$	260.4	150.991	0.009	reject Ho; accept Ha 0.01 confidence level
Male Araneidae n = 2	$H_o: \mu 1 \leq \mu 2$ $Ha: \mu 1 > \mu 2$	1.5	36.5	0.037	reject Ho; accept Ha 0.05 confidence level

Table 3. Results of two-sample *t*-test of spiders by group for average cell area (mean of 30 cells/web, in mm²).

Spider	Hypothesis	Mean ± Standard Deviation Before	Mean ± Standard Deviation After	P	Analysis
Neoscona sp n = 14	H_o: $\mu 1 \leq \mu 2$ Ha: $\mu 1 > \mu 2$	64.77 ± 56.99	125.42 ± 63.89	9.0257×10^{-4}	reject Ho; accept Ha 0.01 confidence level
Female Araneidae n = 5	H_o: $\mu 1 \leq \mu 2$ Ha: $\mu 1 > \mu 2$	38.33 ± 13.49	64.32 ± 20.90	0.038	reject Ho; accept Ha 0.01 confidence level
Gasteracantha elipsoides n = 7	H_o: $\mu 1 \leq \mu 2$ Ha: $\mu 1 > \mu 2$	107.93 ± 35.03	166.67 ± 38.41	0.008	reject Ho; accept Ha 0.01 confidence level
Male Araneidae n = 6	H_o: $\mu 1 \leq \mu 2$ Ha: $\mu 1 > \mu 2$	102.76 ± 42.39	142.01 ± 66.33	0.147	accept Ho; reject Ha 0.01 confidence level
Tetragnatha sp. n = 2	H_o: $\mu 1 \leq \mu 2$ Ha: $\mu 1 > \mu 2$	167.70 ± 1.41	281.78 ± 2.66	0.002	reject Ho; accept Ha 0.01 confidence level
Male Araneidae n = 3	H_o: $\mu 1 \leq \mu 2$ Ha: $\mu 1 > \mu 2$	154.64 ± 58.68	159.21 ± 22.28	0.715	accept Ho; reject Ha 0.01 confidence level
Male Araneidae n = 2	H_o: $\mu 1 \leq \mu 2$ Ha: $\mu 1 > \mu 2$	233.98 ± 7.71	179.12 ± 66.92	0.719	accept Ho; reject Ha 0.01 confidence level

Table 4. Number of large holes in webs before and after alcohol (mean).

	BEFORE	AFTER
Neoscona sp n=14	0.00	3.86
Female Araneidae n=5	0.80	8.80
Gasteracantha elipsoides n=7	0.00	8.71
Male Araneidae n=6	0.00	2.83
Tetragnatha sp. n=2	0.50	0.50
Male Araneidae FDR State Park, n=3	0.00	3.33
Male Araneidae Lee Road, n=2	0.00	0.00

A second behavioral observation involved the number of spiders. In the original webs, spun before the consumption of alcohol, there was always a single spider in the web. Multiple spiders (two or three) appeared in the webs after the spiders had consumed vodka in 14 separate instances.

Conclusions & Discussion

Z-tests are used to analyze data where there are 30 samples or more. Therefore the two-sample Z-test was the best choice for the analysis of the totality of spider webs. The analysis of number of rays, number of cells, and average cell area indicated that the differences in the webs before and after the consumption of alcohol were significant at the 0.01 confidence level. Additionally, there were behavioral differences observed in the actual spinning of the webs.

The analyses of the webs of the individual species were significant as well. With respect to the number of rays, all species of spiders had more rays in the web construction before vodka consumption than after consumption. Species with five to 14 specimens/species were significant at the 0.01 confidence level. It is reasonable to assume that had there been a greater sample size for the species with only two or three specimens, they also would have been significant at the 0.01 confidence level.

With respect to the number of cells per web, there was again a significant difference in the number of cells produced before and after vodka consumption. This held true for the size of the cells as well.

Spiders tended to spin the new webs more quickly after vodka consumption as well as to rip holes in the webs. It is concluded that the alcohol affected not only the ability of the spider to spin the species' characteristic web, but also that the speed of construction affected the precision of the rays and cells.

In humans, alcohol causes relaxation, lowered inhibitions, loss of body control, and reduced muscular coordination. The webs spun by the spiders after vodka consumption were asymmetrical, had fewer support rays, fewer cells, and the cells that were present were larger and irregularly spaced. Additionally, spiders were observed tearing large holes in their webs and also clasping each other (presumably mating). The similarity of behaviors leads to the conclusion that the orb weaver spiders are affected by vodka in many of the same ways that humans are affected.

Abuse of alcohol by young people continues to be a serious problem. Children as young as five and six years old have been documented drinking alcohol, and often see nothing wrong with the behavior. Sometimes, the best people to talk to young people are other young people, as organizations such as Peer Helpers have demonstrated.

As a continuation of this project, a public service program was created with funding from State Farm Insurance. Public service announcements and posters featuring "before" and "after" photographs of the spider webs were developed. Presentations have been made by high school students to younger students in elementary and middle schools in at least five states over the last two years. To see the public service program, go to www.nabt.org/sup/resources/ifyoudrink_thinkpsa.asp.

References

Anonymous. (1995). MFS-28921. *Tech Briefs*. Huntsville, AL: National Aeronautic and Space Administration.

Connor, S. (1995). Results of experiments with Spiders and Drugs. Available online at: www.geocities.com/SunsetStrip/Palace/9295/spider/spiderDrug.htm.

Foelix, R. (1973). *Biology of Spiders, 2nd Edition*. New York, NY: Oxford University Press.

Harrison, R. (1997). Community Alcohol Information Program. Available online at: www.nh-dwi.com/carp-213.htm.

Levi, H.W. (2002). *Spiders and Their Kin*. USA: St. Mark's Press.

Mullen, G.R. (1969). Morphology and history of the silk glands in *Araneus sericatus* CL. *Transactions of the American Microscopial Society*, *88*(2), 232-240.

Witt, P.N. (1956). *Die Wirkung von Substanzen auf den Netzbau der spinne als biologischer Test*. Berline-Gottinger-Heidelberg: Springer-Verlag.

Witt, P.N., Reed, C.F. & Peakall, D.B. (1968). *A Spider's Web, Problems in Regulatory Biology*. New York: Springer-Verlag.