Galls as Mobilizing Sinks?
Plant-Animal Interactions
Annotated Bibliography
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Dorchin, N., Cramer M. D., and Hoffmann, J. H. 2006. Photosynthesis and sink activity of wasp induced galls in *Acacia pycnantha*. Ecology. 87 (7): 1781-1791.

This study uses photosynthesis rates to see sink activities caused by wasp galls (by *Trichlogaster signiventris*) on an acacia species, *Acacia pycnantha.* They analyzed the phyllodes on these plants because they provide more surface area for photosynthesis. Results showed that photosynthesis in galls found in between phyllode and leaf is higher in phyllodes that grow just before the leaf. They also found that galls on vegetative parts are stronger sinks than galls on reproductive parts because of the competition of fruits for development/photosynthesis. Without inflorescent buds in the summer and fall, wasps can alleviate intraspecfic competition in vegetative gall formation, which increases, which increases the availability of plant resources for wasps to develop. Moreover, these wasp gall-formers can induce gall formation in 2 different plant tissues, which is not common.

Florentine, S. K., Raman, A., and Dhileepan, K. 2005. Effects of gall induction by Epiblema strenuana on gas exchange, nutrient, and energetics in *Parthenium hysterophorus*. Biocontrol. 50: 787-801.

This study looks into plant physiology and metabolism to test the nutrition hypothesis. This is a unique system, which involves stem galls induced by a moth species, *Epiblema strenuana* on an aster species, *Parthenium hysterophus.* They examined three stages of plant development; rosette, pre-flowering, and flowering. They found that galls reduced; leaf water potential, photosynthesis rates, transpiration rate, and stomatal conductance, which provided evidence of galls as mobilizing sinks. Energy levels in galls and shoots below galls were higher than those parts above galls. Finally, a change in physiological processes affected mineral uptake. Results concluded that the moth regulates aster physiology.

Hartley, S. E., and Lawton, J. H. 1992. Host-plant manipulation by gall –insects. A test of the Nutrition Hypothesis. Journal of Animal Ecology. 61 (1): 113-119.

This study was the only study I used to show that the nutrition hypothesis was not supported. The species involved are cynipid galls of *Neuroterus quercus-baccarum & Andricus lignicola* on an oak, *Quercas robur.* Nitrogen content in galls were analyzed to test whether fall formers can change levels to their advantage by stopping the increase in nitrogen on fertilized trees, which in turn, reduces insect survival. There was no relationship between gall density and gall nitrogen content.

Koyama, Y., Yao, I., and Akimoto, S. 2004. Aphid galls accumulate high concentrations of amino acids: a support for the nutrition hypothesis for gall formation. The Netherlands Entomological Society. 113: 35-44.

An aphid species, *Rhopalosiphum insertum* colonizes leaves of *Sorbus commixta* OR in galls of *Sorbaphis chaetosiphon*. This study emphasized that aphid galls are expected to have higher nitrogen levels than other types of galls because it is needed to support the number of aphids reproducing parthenogenetically over 2 generations. This study used an amino acids assay due to the importance of amino acids in aphid growth. Aphids reared on galled plants grew more rapidly and the second generation grew larger and more fecund. A fivefold increase in amino acids exuding from cut galled leaves were found, but there was no difference in amino acid compounds between galled and un-galled leaves.

Larson, K. C., and Whitham, T. G. 1991. Manipulation of food resources by a gall-forming aphid. The physiology of sink-source interactions. Oecologia. 88 (1): 15-21.

This system involves an aphid species, *Pemphigus betae* on cottonwoods, *Populus anguistifolia.* Carbon labeling was used to show the sink-source relationship between galls and cottonwood leaves. Results show that aphid galls are sinks taking in resources from surrounding plant sources, early gall development depends on the galls increasing the allocation from storage reserves in the stem, where as later development of aphids inside gall depended on resources from galled leaf blade. Aphid success was shown in basal galls (65% increase in progeny) and removing female catkins a 31% increase of aphid success was observed. Fruits competed with galls for food supply.

Rehill, B. J., and Schultz, J. C. 2003. Enhanced invertase activities in the galls of *Hormaphis hamamelidis*. Journal of Chemical Ecology. 29 (12): 2703-2720.

Different invertases and their activities were assayed in a system with a galling aphid, *Hormaphis hamamelidis,* which induces galls on a witch hazel, *Hamamelis virginiana*. Invertases are sucrose hydrolyzing enzymes associated with plant tissues acting as physiological sinks, like galls. They looked at several types of invertases and their potential benefits in the aphid galls. Certain invertases were important in different times of gall development as well as in seasonal changes. There was also an observed increased reproductive output with an increasing invertase activity.

Stone, G. N., and Schonrogge, K. 2003. The adaptive significance of insect gall morphology. Trends in Ecology and Evolution. Vol. 18, No. 10. 512-522.

Discusses three hypothesis to explain the significance of gall induction; nutrition, microenvironment, and enemy hypotheses. I use this paper to focus on the nutrition hypothesis. This paper explains that differentiated tissues in the gall are more nutritive and less well defended than un-galled tissue on the same plant. This area of higher nutrients should be favored by selection. If there is selection for nutritive tissue, no one has done analysis of relationships between gall form and reproductive output. However, nutritive benefits are NOT supported in cynipid gall wasps and cecidomyiid gall midges (however my system involves tenthrediid wasp in the Tenthredinidae).