Flower and Tongue Length, evidence of co-evolution, or just another pollinator syndrome?

Annotated Bibliography

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Plant Animal Interactions

Beattie, A. J. (1971). "Pollination Mechanisms in Viola-D." New Phytologist **70**: 343-360.

Visits to Viola based on corolla length and proboscis length. Fantastic diagrams of bee visits. Findings: Longer proboscis=better pollination per visit. Discusses pollination of several insects and the breakdown of the bee flower pollination syndrome.

Dukas, R. and A. Shmida (1989). "Correlation between the color, size and shape of Israeli crucifer flowers and relationships to pollinators." Oikos **54**: 281-286.

Information on evolution of floral traits based on influence of pollinator traits.

Grant, V. (1983). "The systematic and geographical distribution of hawkmoth flowers in the temperate North American flora." Botanical Gazette **144**: 439-449.

More information on which moths do what pollination in North America rather than good information on proboscis length relationships or pollination efficacy.

Grant, V. and K. A. Grant (1983). "Behavior of hawkmoths on flowers of Datura meteloides." Botanical Gazette **144**: 280-284.

Good anecdotal information on hawkmoth pollination. Purely an observational study with no statistical tests, etc.

Harder, L. D. (1985). "Morphology as a predictor of flower choice by bumble bees." Ecology **66**: 198-210.

Very interesting study. Developed models and equations to test how well morphological characters predicted flower choice in bumblebees. Found that bumblebees with short tongues were more predictable than bumblebees with long tongues because of restricted resource availability.

Heinrich, B. (1976). "Resource partitioning among some eusocial insects: Bumblebees." Ecology **57**: 874-889.

Another interesting study. This is by the man that wrote Bumblebee Economics. Measures resources available and resources used and finds that in his system resources are limiting. Good information on theory behind specialists vs. generalists and where we would expect to find each.

Herrera, C. M. (1989). "Pollinator abundance, morphology, and flower visitation rate: Analysis of the "quantity" component in a plant-pollinator system." Oecologia **80**: 241-248.

Good information on lepidoptera pollination. Makes some interesting inferences that I'm not sure he backs up about butterfly tongue length. Here he says that body size is more important that tongue length b/c large body

size=long tongue. This paper is about more than leps though and investigates which is more important, quality or quantity. He also has a quality paper out, but I didn't read it. He makes some comparisons in the discussion.

Hiei, K. and K. Suzuki (2001). "Visitation frequency of Melampyrum roseum var. japonicum (Scrophulariaceae) by three bumblebee species and its relation to pollination efficiency." Canadian Journal of Botany **79**: 1167-1174.
Discusses pollination efficacy of 3 bombus spp. Also talks about pollen limitation and how this affects community dynamics. Finds evidence for changing flower morphology across landscapes due to bumblebee spp.

Inouye, D. W. (1978). "Resource partitioning in bumblebees: Experimental studies of foraging behavior." Ecology **59**: 672-678.
Paper we read for class: Interesting experimental comparisons of bumblebee resource use. Neat manipulative study with interesting results on resource partitioning. This along with his dissertation from North Carolina started the debate with Ranta on competition vs. environmental variation.

Inouye, D. W. (1980). "The effect of proboscis and corolla tube lengths on patterns and rates of flower visitation by bumblebees." Oecologia **45**: 197-201.
Good overview of how bumblebees use their tongues to obtain nectar from flowers. Also a good overview of what resource partitioning is and how it plays into community dynamics. Findings include the fact that long tongue bees forage faster on long corolla tube flowers and that short tongue bees prefer short corolla tube flowers. This papers supports his 78 paper.

Johnson, S. D. and K. E. Steiner (1997). "Long-tongued fly pollination and evolution of floral spur length in the Disa draconis complex (Orchidaceae)." Evolution **51**: 45-53.
This is one of the neatest papers that I read for this presentation. Great data on evolution of plant and animal traits together. Probably the most clear example of if not coevolution, at least the evolution of one species to the resources that are available to it.

Johnson, S. D. and K. E. Steiner (2000). "Generalization versus specialization in plant pollination systems." Trends in Ecology & Evolution **15**: 140-143.
Cynical quotes on pollinator syndromes! Good overview of specialization vs. generalization and in what circumstance we would expect each. Provides little evidence to support theory, but the paper is a good general overview.

Kato, M. (1992). "Plant-pollinator interactions in the understory of a lowland mixed dipterocarp forest in sarawak." American Journal of Botany 83(6): 732-743.
Talks about how many pollinator syndromes collapse under testing in this system. Tests many different morphology traits and finds that tongue length was one of the only traits of animal pollinators to correlate with floral traits. Also found a relatively high degree of specialization in this system.

Krenn, H. W., K. P. Zulka, et al. (2001). "Proboscis morphology and food preferences in nymphalid butterflies (Lepidoptera: Nymphalidae)." Journal of Zoology **254**: 17-26.
Compares flower visiting nymphalid butterflies to non-flower visiting nymphalid butterflies. Finds that flower visiting species have shorter

proboscides than non-flower visiting. Interesting comparison of 60 different nymphalid butterflies in all physical and behavioral traits.

Macior, L. W. (1983). "The pollination dynamics of sympatric species of Pedicularis (Scrophulariaceae)." American Journal Of Botany **70**: 844-853.
Discusses an obligate pollination relationship between Pedicularis and Bombus. Found a high degree of plant fidelity throughout blooming period by Bombus. Compares Pedicularis of different corolla tube lengths and corresponding visits by bumblebees. Uses a different method to test resource partitioning (Queen visits/Worker visits x # spp.) than Ranta or Inouye but results support Ranta's theory. Not sure that this method is really set up to test this theory and the author may have overreached his data.

Manning, J. C. and P. Goldblatt (1996). "The Prosoeca peringueyi (Diptera: Nemestrinidae) pollination guild in southern Africa: Long-tongued flies and their tubular flowers." Annals of the Missouri Botanical Garden **83**: 67-86.
Another great paper on fly pollination. Very interesting study and neat results.

May, P. G. (1992). "Flower selection and the dynamics of lipid reserves in two nectarivorous butterflies." Ecology **73**: 2181-2191.
Compares 2 butterfly species for lipid reserves throughout different life stages. Shows that butterflies with longer proboscides can more easily find better resources during adult phase. Wasn't able to tie this to fecundity, but realized the need to do so.

Morris, W. F. (1996). "Mutualism denied? Nectar-robbing bumble bees do not reduce female or male success of bluebells." Ecology **77**: 1451-1462.
Very cool manipulative study in Alaska. Shows results that bumblebees rob nectar, but also pollinate the flowers during a different stage. Neat example of the need to observe things throughout the life-cycle and to not have blinders on as to results. At first glance it appeared that nectar robbing was the only thing happening.

Nilsson, L. A. (1988). "The Evolution of Flowers with Deep Corolla Tubes." Nature **334**: 147-149.
Good overview paper in nature. Interesting discussion of the need for long-tongued pollinators and the potential problems that could arise if they start to disappear. Author feels that this study affirms Darwin's theory of coevolution of floral traits with pollinator traits.

Paton, D. C. and B. G. Collins (1989). "Bills and tongues of nectar-feeding birds: A review of morphology, function and performance, with intercontinental comparisons." Australian Journal Of Ecology **14**: 473-506.
Good review of morphology of birds and function. Not too much on tongue length, nor anything of pollination efficacy of different traits or morphologies. Interesting info for bird enthusiasts, but not much scientific value.

Pettersson, M. W. (1991). "Pollination by a guild of fluctuating moth populations: Option for unspecialization in Silene vulgaris." Journal Of Ecology **79**: 591-604.
Shows that proboscis length in moths is not correlated to pollination efficacy and that moth pollinated plants must depend on multiple visits from moths.

Pyke, G. H. (1982). "Local geographic distributions of bumblebees near Crested Butte, Colorado, USA: Competition and community structure." Ecology **63**: 555-573.
Talks about mechanisms for extinction in bumblebees. Evidence that plants with longer corolla tubes produce more nectar. For the most part this is a qualitative paper with some neat ideas and interesting discussion regarding competition theory.

Ranta, E. (1982). "Species structure of North European bumblebee communities." Oikos **38**: 202-209.
Discusses "specialization" of long-tongue bumblebees. For the most part this is a community ecology paper on resource partitioning. Interesting theory and some evidence to back it up.

Ranta, E. (1984). "Proboscis length and the coexistence of bumblebee species." Oikos **43**: 189-196.
Neat comparison of the resources available to the resources used by bumblebees. Used mathematics to come up with expected patterns of resource use based on proboscis length and competition theory to compare them to observed results. Results deviate from what would be expected under competition theory and support the uneven availability of resources throughout the season. Good read.

Ranta, E., H. Lundberg, et al. (1981). "Patterns of resource utilization in 2 Fennoscandian bumblebee communities." Oikos **36**: 1-11.
Paper we read for class that compares resource use in two communities and makes conclusions on resource partitioning. Finds that in communities with predictable resources bumblebees will separate via competition theory, but when resources are unpredictable bumblebees will not separate out by tongue length.

Ranta, E. and K. Vepsalainen (1981). "Why Are There So Many Species Spatio Temporal Heterogeneity and Northern Bumble Bee Communities." Oikos **36**: 28-34.
More information on tongue length and # of species. I feel that the evidence presented in this paper does not support his findings. The scale is too large and the species he says coexist are living several kilometers from each other. Tried to use this paper to disprove Inouye's theory, but didn't do such a good job.

Robertson, J. L. and R. Wyatt (1990). "Evidence for pollination ecotypes in the yellow-fringed orchid, Platanthera ciliaris." Evolution **44**: 121-133.
Very neat study. "Not only did floral morphology differ between sites, but the direction of the differences was consistent with the hypothesis that floral traits are adapted to the local pollinators in each site. Good evidence that butterflies are indeed pollinators!