

UNIVERSITY OF CALIFORNIA
RIVERSIDE

The Structure of Plant-Pollinator Interactions in Montane Meadow Environments

A Dissertation submitted in partial satisfaction
of the requirement for the degree of

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in

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by

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DEDICATION

To my parents, for introducing me to the mountains at a very young age and encouraging me to follow my dreams, and to my grandmothers for sharing their love of nature with me.

ABSTRACT OF THE DISSERTATION

The Structure of Plant-Pollinator Interactions in Montane Meadow Environments

by

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The assumption that plant-pollinator relationships are ecologically specialized is central to the tradition view of angiosperm diversification. The pollination syndrome hypothesis maintains that specialized pollinators drive floral evolution, and thus it is possible to predict the pollinator based on stereotypical combination of floral characteristics. Recently however, biologists have suggested that mutualistic interactions are rather generalized and that even complex floral morphologies may not necessarily represent adaptations to specialized pollinators. To test these ideas, I conducted a community-level survey in a montane meadow system in both California and in Colorado. Analyses of plant-pollinator interaction networks suggest that these communities are highly nested, with most species involved in asymmetrical interactions with generalist partners, whereas reciprocally specialized plant-pollinator interactions were relatively rare.

To test the predictive utility of the pollination syndromes in a community context, I scored plant species for the presence/absence of 40 floral characteristics and attempted to classify each species into a syndrome based on its overall similarity to idealized syndrome descriptions derived from the literature. For most plant species the syndrome classifications failed to accurately predict the most frequently observed pollinator. Traits that influence access to floral rewards appeared to be more important in structuring plant-pollinator interactions, as opposed to floral signals of the presence of a reward, such as color or scent.

A corollary of the pollination syndrome hypothesis states that flowers will evolve adaptations to the most frequent *and* effective pollinator. To test this idea, I removed and analyzed the pollen carried by insect pollinators. I used MANOVAs to test for an association between the frequency of visitation and pollen load composition and found that the number of conspecific pollen grains and the proportion of conspecific pollen carried by insects was positively associated with the frequency of interaction. If pollen deposition is correlated with insect pollen load composition, then visitation patterns might reflect pollination patterns. However, the assumptions regarding ecological specialization of plant-pollinator interactions, and the predictive utility of syndromes are not supported in a community context, suggesting that some traditional views in pollination biology should be reevaluated.

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INTRODUCTION TO THE DISSERTATION

As early as the 1700's biologists such as Kölreuter (1761; see Mayr 1986) and Sprengel (1793) realized that flowers contained plant reproductive organs and that their features in many cases served to attract pollinating animals. Darwin (1859) knew of the work of these early pollination biologists and suggested that the fit between flower and pollinator phenotype was the product of natural selection.

Darwin's (1862) subsequent volume, devoted entirely to pollination biology, presented numerous examples of how the complex reproductive structures in orchids are "perfectly adapted" for effective pollen removal and deposition by insect vectors. His work inspired others (e.g. Müller 1873) to look for morphological matching between insects and flowers (Proctor et al. 1996). Delpino (1868-1875; see Knuth 1906) is credited with developing the concept of floral types, which are distinct floral morphologies associated with different pollinators.

In the mid-20th century the "pollination syndrome" hypothesis rejuvenated interest in plant-pollinator interactions and floral evolution. The proponents of this syndrome built upon the floral types or "adaptation groups" developed by Delpino. Based on the observation that flowers possessing a specific suite of floral traits appear to be visited and pollinated by a corresponding group of pollinators, these workers suggested that the suites of traits represent adaptive character syndromes aimed at attracting and using particular pollinators (van der Pijl 1960, 1961, Faegri and van der Pijl 1966, Grant and Grant 1965).

Since floral features are used to define angiosperm species, as well as pollination syndromes, it is reasonable to propose that pollinators are involved in speciation (Grant 1949, Baker 1963, Fenster and Dudash 2001, Waser 2001). It is believed that associations with novel or different pollinators can result in reproductive isolation because behavioral and mechanical barriers will limit gene flow (Grant 1949, 1952, 1994). Grant (1949, 1952) suggested that plant species could capitalize on variation in pollinator preferences by morphologically specializing on specific pollinators while excluding less favorable ones. A corollary of the hypothesis, the “most effective pollinator principle” (Stebbins 1970), proposes that the most frequent and effective visitor will drive floral evolution. Thus from a plant’s perspective the degree of pollinator effectiveness should reflect the extent of adaptation to that particular pollinator. If plants have different effective pollinators they will evolve divergent floral phenotypes and become reproductively isolated from one another.

The pollination syndrome hypothesis assumes that plant-pollinator mutualisms are specialized, such that each plant species coevolved with its current pollinator or group of related pollinators such as bees, butterflies, moths, etc. (Waser et al. 1996, Ollerton 1996, Waser 1998, 2001). This assumption has both ecological and evolutionary implications. From an ecological perspective it implies that plant species should be visited, and pollinated, by a small number of related species. This is referred to ecological specialization (Armbruster et al. 2000). From an evolutionary perspective, specialization refers to the evolution of floral adaptations to specific pollinators (Grant 1949, Baker 1963, Grant and Grant 1965, Aigner 2001), where these adaptations include those traits

that beneficially influence pollinator behavior and/or pollen transfer mechanics for the plant (Waser 1983). Under the pollination syndrome paradigm, ecological specialization is responsible for evolutionary specialization, yet only recently have the ecological conditions that promote the evolution of floral specialization been addressed (Howe 1984, Futuyma and Moreno 1988, Ollerton 1996, Waser et al. 1996, Waser 1998, Armbruster et al. 2000, Johnson and Steiner 2000, Aigner 2001).

Although the pollination syndrome hypothesis attempts to link plant-pollinator associations, floral evolution, and angiosperm speciation, there are some problems. Recently biologists have argued that most plant-pollinator mutualisms are not ecologically specialized, but instead relatively generalized, which undermines a central assumption of the hypothesis (Herrera 1996, Waser et al. 1996; but see Johnson and Steiner 2000). Specialization has been argued for some time to be an artifact of sampling bias (Robertson 1928, Moldenke 1976). Reanalysis of two older community level pollination studies (Clements and Long 1923, Robertson 1928; see Waser et al. 1996), along with the work of Moldenke from the 1970's (Moldenke 1975, 1976, 1979, Moldenke and Lincoln 1979), and more contemporary work (Jordano 1987, Petanidou and Ellis 1993, 1996, Petanidou and Vokou 1993, Memmott 1999, Kanstrup and Olesen 2000, Olesen 2000, Bascompte et al. 2003, Dupont et al 2003, Jordano et al. 2003), suggests that specialized plant-pollinator interactions are rare. This has generated a healthy discussion of the degree of specialization in pollination systems and its evolutionary implications (Ollerton 1996, Chittka and Waser 1997, Ollerton 1998, Waser 1998, Armbruster and Baldwin 1998, Gómez and Zamora 1999, Memmott 1999, Johnson

and Steiner 2000, Armbruster et al. 2000, Olesen 2000, Ollerton and Watts 2000, Kanstrup and Olesen 2000, Fenster and Dudash 2001). Ollerton (1996) articulated the apparent paradox between the ecological and evolutionary views of plant-pollinator interactions: if plant-pollinator systems are ecologically generalized how then do specialized morphological floral traits evolve?

Few studies have actually tested the syndrome hypothesis by comparing actual pollinators to the taxa that the syndromes predict (but see Sakai et al. 1999, Hingston and McQuillan 2000). Ollerton and Watts (2000) recently mapped the classic pollination syndromes in phenotypic space, to determine if they occupied distinct positions. Analysis of the eleven classical syndromes (bird, hawkmoth, moth, butterfly, bee, bat, mammal, beetle, carrion fly, wasp and fly) showed that they clustered into four groups, fewer than half of the putative eleven. What this implies is that we cannot *a priori* categorize a plant as being pollinated by, or under phenotypic selection by, a single type of pollinator, based on floral traits alone (Barthell and Knops 1997, Ollerton 1998, Fishbein and Venable 1996). It is likely that community level surveys will reveal that most plants do not fall neatly into pollination syndromes and that pollinators do not restrict themselves to visiting only the plants that match syndrome expectations (Ollerton 1998).

Until recently, attempts to describe the complex nature of mutualistic networks and compare them to idealized syndrome expectations could only go so far in the absence of advanced computer technology and novel analytical techniques.

Recently, however, these tools along with developments from other areas of science have made it possible to better describe plant-pollinator interaction networks and to reconcile empirical patterns with the traditional views regarding floral evolution. Several recent studies have utilized these tools to describe mutualistic plant-pollinator and plant-seed disperser interaction networks communities and suggest that the assumption that most plant and pollinator species are involved in reciprocally specialized interactions might not necessarily be true (Bascompte et al 2003, Dupont et al. 2003, Jordano et al. 2003, Ollerton et al. 2003), suggesting that the traditional views in pollination biology need to be reevaluated.

However, the analysis of plant-pollinator interaction networks based on floral visitation alone, rather than actual pollination, might be misleading. Visitation is just one component of successful pollination. The visitor must also transfer viable pollen to a receptive stigma. Unfortunately quality and quantity of pollinator visits might not be tightly coupled even though both components contribute to intensity of plant-pollinator interactions (Waser and Price 1983, Herrera 1987, 1989, 1996). Quality refers to the per-visit influence on plant fitness, while quantity refers to the frequency of such interaction (Herrera 1987, 1989). Insects vary in their ability to transfer pollen and some visitors may actually be “robbers” or “cheaters” in the sense that they do not provide a service for the resources they receive (Barrows 1976, Herrera 1987, Bronstein 1994, Thompson 1996, Irwin et al. 2001). It is possible that many of the interactions we perceive as constituting pollination in community level surveys may actually have negative or null effects. Characterizing and relating pollinator efficiency to visitation patterns would

provide a better estimate of the fitness consequences from a plant's perspective. Without efforts to quantify and incorporate aspects of pollen transfer into interaction networks, such exercises will continually fall short of describing true plant-pollinator relationships.

The overall goal of my dissertation is to test aspects of the pollination paradigm using a community level approach, including the assumption that species are ecological specialized, the predictive value of pollination syndromes, and the assertion that “quantity” and “quality” components of pollination are positively associated with each other. In the first chapter I use network techniques to describe the structural and topological patterns of two plant-pollinator montane meadow communities, and relate the patterns to the current discussion of ecological generalization in plant-pollinator interactions. In the second chapter I compare the observed visitation pattern of different pollinator taxa to the expected visitation patterns based on the floral characteristics associated with pollination syndromes, to test the predictive value of ‘syndromes’ in a community context. In the third chapter I conclude by using the composition of insect pollen loads as an estimate of pollinator “quality,” and compare these values to pollinator “quantity” (the frequency of pollinator visitation), to test the idea that these two components are positively correlated with each other as Stebbins’ (1970) ‘principle’ would suggest. Collectively, these chapters provide a new perspective as to the nature of plant-pollinator relationships and challenge many of the traditional views in pollination biology. I hope that the results presented here will stimulate others to take up some of these challenges and so contribute further to current advances in our understanding of an important ecological interaction.

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CHAPTER 1

STRUCTURE AND TOPOLOGY OF PLANT-POLLINATOR INTERACTION NETWORKS

Introduction

Pollination biology has had a long tradition of studying plant-pollinator systems with a single focal plant species and usually one or a few closely related pollinating taxa. This tradition began with Darwin's (1862) descriptions of ecologically and phenotypically specialized insect-pollinated orchids. This approach may be ideal for species pairs that have coevolved with one another, but not for species that interact with a diverse group of mutualistic partners across space and time (Thompson 1994). Indeed, one-to-one plant-pollinator relationships are the exception, apparently found only in the highly specialized yucca-yucca moth, fig-fig wasp, and a few other systems; and even the highly specialized fig-fig wasp systems may sometimes involve more than one pollinating wasp species per fig (Molbo et al. 2003). It is becoming increasingly apparent that plant and pollinator communities are highly interconnected, and that many species interacting with multiple partners (Herrera 1988, Waser et al 1996, Memmott 1999, Bascompte et al. 2003, Dupont et al 2003, Jordano et al. 2003, Ollerton et al. 2003). Elucidating the patterns of interactions in a community context is vital for understanding the mechanisms underlying angiosperm diversification and the evolution of the floral phenotype (Thompson 1994, Ollerton 1996, Waser 1998). The traditional view of pollinator mediated selection assumes that plant-pollinator mutualisms are highly specialized, such that each plant species coevolved with its current pollinator or group of related pollinators such as bees, butterflies, moths, etc. (Waser et al. 1996, Ollerton 1996, Waser 1998, 2001). However if community level studies continue to suggest that plant and pollinator species are not ecologically specialized, then pollination biologists will

have to reconsider how pollinators interact with plants within a complex and dynamic setting to influence floral evolution.

Early attempts to describe the complexity of plant-pollinator interaction networks could only go so far without the aid of advanced computer technology. These studies usually produced extensive lists of pair-wise plant-pollinator interactions (e.g. Clements and Long 1923, Robertson 1929) or described patterns of species diversity and composition along some sort of altitudinal or geographic gradient (e.g. Moldenke 1975, 1976, 1979, Moldenke and Lincoln 1979). Developments from several areas of science have recently produced novel tools and techniques suitable for describing interaction networks. Analysis of complex networks, from the Internet to metabolic pathways, reveals that biotic and abiotic systems share many structural and topological properties that can be readily described (Stogatz 2001). Recent attempts to describe the structure and topology of plant-pollinator communities has benefited from advances in various areas of science including food web ecology, null models, biogeography, social and network science (Dicks et al. 2002, Bascompte et al. 2003, Dupont et al 2003, Jordano et al. 2003, Ollerton et al. 2003, Vázquez and Aizen 2003).

However each of these novel approaches highlights different aspects of the networks, which make it difficult to identify and integrate the various topological and structural properties of mutualistic interaction networks. In some cases the findings from one study seem to contradict the results of another because they utilized different techniques. For example, analyses used to identify structural compartments within interaction networks (e.g. Raffaelli and Hall 1992, Dicks et al. 2002) emphasize

ecologically specialized plant-pollinator interactions. In highly compartmentalized communities most plant species would be visited by different pollinator species. Nestedness analysis, on the other hand, suggests a very different type of community structure. Traditionally this approach has been used to determine if the species present on small islands are a subset of the species pool of larger islands (Patterson 1990). In pollination biology the plant species are analogous to islands, and one calculates the extent to which the flower visitors to the various species are subsets of each other (Bascompte et al. 2003, Dupont et al. 2003, Ollerton et al. 2003). Rather than being subdivided, nested communities tend to be highly interconnected through shared interactions with generalist plant and pollinator species (Bascompte et al. 2003, Dupont et al. 2003, Ollerton et al. 2003). Novel techniques developed for the analysis of social networks (e.g. Borgatti et al 2002) make it relatively easy to then identify these generalist or *core* species, which might be analogous to “keystone” species.

Analysis of the link distributions within plant-pollinator networks (e.g. Jordano et al. 2003) and the null models recently developed by Vázquez and Aizen (2003) are complementary techniques used for describing the distribution specialist and generalist species within the community, and also provide valuable insight as to the mechanisms generating the observed patterns. In network terminology, “nodes” are the elements or entities of the system that are being studied, in this case plant and pollinator species, whereas a “link,” between two nodes signifies that they interact with each other in some fashion. In plant-pollinator community level studies a link between two species indicates that a pollinator was observed to visit a plant species at least once. By comparing the fit

of the frequency distribution of links per species, or the number of different species that plants or pollinators interact with, to power or exponential curves one can ascertain if generalist species are relatively rare in the community. The shape of the curve also suggests how species link to each other, whether species are establishing links randomly to mutualist partners or preferentially to generalist species (Jordano et al. 2003). The null models developed by Vázquez and Aizen (2003) on the other hand specifically take into account the frequency of interaction, as measured by the number of times individual pollinators of a particular species were observed visiting plants, to see how species abundance influences the degree of generalization. The more common a species is, the more likely it will be observed to interact with a different partner as opposed to a rare species, and thus it is necessary to account for such differences in abundance. It is possible that the question of generalization is actually a question of commonness or rarity. Given the wide range of techniques recently employed to describe plant-pollinator networks, it would be ideal then to apply the various techniques in a complementary fashion so as to fully explore the structural properties of mutualistic communities and the types of interactions embedded within them. To date I am aware of only one such attempt (Jordano et al. 2004).

Here I describe two communities of plants and pollinators from the mountains of California and Colorado. I explore these communities for patterns that may suggest mechanisms generating community structure. To this end I borrow some methods from other recent pollination studies and add some approaches developed for the social sciences that are new to pollination biology. Most of the analyses use presence/absence

data, however I use the frequency of interaction between plants and animals as a measure of interaction strength whenever possible.

Specifically, I address the following questions: 1) what is the distribution of links per species, and what does the distribution suggest about how plants and pollinators interact with each other? 2) Are the plant and pollinator species from these two montane communities more specialized or generalized than expected by chance, and how does abundance influence the degree of generalization? 3) Are these mutualistic communities significantly nested, and if so what species constitute the core of generalists? 4) Are there compartments with specialized plant and pollinator species embedded within the interaction network?

Materials and Methods

Study Sites

This study was conducted in two montane meadow systems in different mountain ranges: the Rocky Mountains of central Colorado and the San Bernardino Mountains in southern California. The Colorado system was a large and continuous high elevation sub-alpine meadow bordered by coniferous forest and talus slopes. The California meadows were located in smaller openings within yellow pine forests. In both systems plant-pollinator interactions were recorded in multiple years, but for Colorado I only present results from the first year.

During the summer of 2000, interactions were recorded in Virginia Basin (38° 58.6' N, 106° 58' W) near the Rocky Mountain Biological Laboratory in Gothic, CO. I

established three study sites, spaced approximately 100m apart, along an elevational gradient through the basin: Low site (3385m), Middle site (3445m), and High site (3475m). In each site I set up three parallel 50m $\times$ 1m wide belt transects spaced 10m apart. I sampled flower visitation at all three sites twice a week for a period of 5 weeks (June 30-August 3), which encompassed the peak flowering period. Hereafter I will refer to the Colorado meadow system as Virginia Basin.

In 2001 I established four sites, within 2 km of each other, within the Big Bear Ranger District of San Bernardino Mountains along Forest Service Road 2N10 at Metcalf Meadow (2,243m) Roadside (2,292m) YMCA Junction (2,316) and Camp Bluff Lake (2,316m; 34° 13.2' N, 116° 57.5' W). Due to a high number of endemic sensitive and endangered plant species in the San Bernardino Mountains I was unable to establish transects that ran directly through the meadows; instead I set up 3-5 50m $\times$ 1m belt transects along existing paths to minimize any trampling impact. At each site, transects were surveyed for plant-pollinator twice a week from June 21-August 1. In 2002 I abandoned Metcalf Meadow because of a high level of human use and instead established more transects at Camp Bluff Lake (The Wildlands Conservancy), dividing the site into two: Bluff Woods and Bluff Meadow. At each site plant-pollinator interactions were sampled once to twice a week from May 29-July 31. In 2003 I concentrated sampling efforts at both sites at Camp Bluff Lake and surveyed plant-pollinator interactions twice a week from June 16-August 6. Hereafter I will refer to the California study system as Bluff Mesa.

Flower-Pollinator Surveys

Surveys were carried out from 09:00h-17:00h under favorable weather conditions. I attempted surveys at dawn and dusk, but the cool temperatures limited insect activity. Flower visitors were sampled by slowly walking transects (20-40 min/transect) and collecting insects that came into contact with floral reproductive structures; hummingbird and hawkmoth visits were simply recorded. Only those insects belonging to the orders most commonly associated with pollination (Coleoptera, Diptera, Hymenoptera, Lepidoptera) were collected and recorded. Large and easily identifiable insects, such as butterflies, bumblebees and honeybees were released after the visit was recorded, while other insects were pinned for subsequent identification. Visitors were placed into operational taxonomic units (OTU's) and identified at least to family; bees and butterflies were identified to genus and species, respectively. For construction of quantitative webs such a level of resolution is satisfactory (Memmott 1999, Memmott and Godfray 1993).

At weekly intervals I also estimated floral abundance and diversity by counting the total number of floral units (individual flowers or compact flower clusters) along 2-3 of the transect belts in Virginia Basin. At Bluff Mesa I also estimated floral abundance at weekly intervals, but did so by counting the number of floral units in 11 1m² plots spaced evenly along the 50m transects at 5m intervals.

Descriptive Statistics

In both Virginia Basin and Bluff Mesa I recorded each instance an animal pollinator visited a flower and used this as the basic unit of observation. Within each community, I then pooled the plant-pollinator observations across sites to create a plant-

animal ($P \times A$) interaction network for each field season. I also combined the observation across the 2001-2003 seasons at Bluff Mesa for analysis. I then calculated the number of different species that each plant and pollinator species interacted with (k_p and k_a , respectively), or the number of links per species. I also computed the frequency that plant and pollinator species were observed to interact with a mutualist partners (f_p and f_a , respectively), which I use as an estimate of species abundance. I calculated measures of central tendency and dispersion for both of these parameters.

Question 1) What is the distribution of links per species, and what does the distribution suggest about how plants and pollinators interact with each other?

To describe the species link distribution for plants and pollinators, and gain insight as to how mutualists interact with each other in a community setting, I used SPSS 10.0 to fit the cumulative link distributions, $P(k)$, for plants and animals to three different models where each model suggests a different type of topology and/or mechanism governing the establishment of links between plants and pollinators: a) a power law, $P(k) \sim k^{-\gamma}$; b) a truncated power law, $P(k) \sim k^{-\gamma} \exp(-k/k_x)$; and c) an exponential, $P(k) \sim \exp(-\gamma k)$ (Amaral 2000, Jordano et al 2003). Communities described by power law and truncated power law distributions suggest that generalist species are important members of the community in that most species have links established to them. In the truncated model however, super-generalists, which interact with most of the available species, are relatively rare (Jordano et al. 2003). Exponential species link distribution on the other hand suggest that generalists are altogether rare within the community and that plant and pollinator species establish links to each other randomly. For each community I analyzed

the cumulative link distribution for both plant and pollinator assemblages separately. I compared the R^2 and F-statistic values of each model fitting to determine which best described the species link distribution for a particular assemblage. For Bluff Mesa I analyzed the data both separately for each field season, as well as the combined 2001 through 2003 datasets.

Question 2) Are the plant and pollinator species from these two montane communities more specialized or generalized than expected by chance, and how does abundance influence the degree of generalization?

When trying to uncover the mechanism generating ecological patterns, a logical first step is to compare the empirical data to some null expectation to test the likelihood that the observed pattern is due to chance (Gotelli and Graves 1996). I used Vázquez and Aizen's (2003a) null models to compare the observed distribution of the number of links per species to the patterns generated in randomly generated null communities. Null model 1 assumes that plant and pollinator species interact randomly each other within a community. First the algorithm assigns each plant and pollinator species from the community a single interaction, and then it continues to assign interactions randomly between species pairs until a random community is created with the same number of species and pairwise links as in the real community. Null model 2 factors in species abundance, as estimated through the frequency of observed interaction, when estimating the degree of generalization. Once each species is assigned an interaction, the remaining interactions are distributed in proportion to the species' observed frequency of interaction. For both models, the algorithm then compares the observed data to the

expected null frequencies by calculating the mean difference (D-value) between the observed data and 1000 null distributions. For the plant and pollinator assemblages I also compared the number of links per species (k , see above) to the frequency of observed interactions (f) to see if degree of generalization and abundance are positively correlated with each other.

Question 3) Are these mutualistic communities significantly nested, and if so what species constitute the core of generalists?

In nested communities, each species interacts with a perfect subset of species that the next most generalized species interacts with. I used the Nestedness Calculator (Atmar and Patterson, 1993) to calculate a measure of nestedness. The program reorganizes a presence/absence matrix so as to arrange plant and pollinator species from the most to least linked. The program also constructs a perfectly nested matrix with the same number of plant species (P), animal species (A), and links between them (L), as in the real community. Then the algorithm calculates the extent to which the reordered community matrix deviates from the perfectly nested matrix, as measured by the disorder of the system or Temperature (T), which ranges from 0^0 , for perfectly nested system, to 100^0 for a randomly organized matrix. I ran the Nested Calculator's Monte Carlo Randomization algorithm for 1000 iterations to calculate the probability that the observed degree of nestedness was generated by chance. I followed Bascompte et al. (2003) and converted the Temperature statistic to the Nestedness index N ($N = (100 - T)/100$), which ranges from 0, when the community is randomly organized, to 1 when it perfectly nested.

To identify the size and identity of the core group of generalist species in the networks I used UCINET (6.0). The *k*-cores routine in UCINET is useful for identifying hierarchical groups of species based on the number of links each member shares with other members of the group (Hanneman 2001). For example, a pollinator is part of a 6-core group if it interacts with 6 or more plant species within the group. The group with the largest *k* value is typically composed of the most generalized species in the network. I then used the *eigenvector centrality* routine of UCINET to rank the species in the highest *k*-core group based on how generalized their partners' are. This approach calculates a value for each species in proportion to the sum of the "centrality" scores of the nodes it interacts with, such that species with high eigenvector values tend to interact with the more generalized species that make up the core, insofar as these exist (Hanneman 2001, Jordano et al 2004).

Question 4) Are there compartments with specialized plant and pollinator species embedded within the interaction network?

To look for evidence of compartments within the plant-pollinator network I employed the Niche Overlap analysis in EcoSim 7.0 (Gotelli and Entsminger 2001). EcoSim performs Monte Carlo randomizations, in which random communities are generated and statistically compared to real data. Communities that are highly structured might have either higher or lower levels of niche overlap than randomly generated communities. The program uses Winemiller and Pianka's (1990) null randomization algorithms. In this exercise I used null model RA3 (Niche Breadth retained/ Zero States reshuffled), in which the number of resources used by a species remains unchanged, but

the identity of resources used is allowed to vary. I used Czechanowski's index ($O_{12} = O_{21} = 1 - 0.5 * \sum |p_{1i} - p_{2i}|$) as an index of niche overlap, where p_{1i} is the proportion of resource i used by species 1 and p_{2i} is proportion of the same resource utilized by species 2. A large mean niche overlap value suggests that species exhibit a high degree of resource overlap, whereas a small level of resource overlap would suggest that most species use different resources. A large variance in resource however would suggest a community structure in which some species pairs are very similar in terms of resource use and others are very different, i.e. the presence of compartments (Gotelli and Graves 1996, Winemiller and Pianka 1990).

Although the Niche Overlap analysis is useful for detecting resource overlap, it does not reveal the identity of the species that would constitute a compartment with specialist plant and pollinator species. To do so I employed UCINET's *component* routine, which hierarchically clusters species weighted by the number of times each pollinator species was observed to visit a plant species. Plant and pollinator species that interact frequently with one another, and thus are reciprocally specialized, are coupled with each other and are detached from species that they share few interactions with.

Results

I observed a total of 2,111 plant-pollinator visits between 41 plant species and 136 pollinator species at Virginia Basin in 2000. Plants in Virginia Basin interacted with a median of 3 pollinator species (range = 1-69) whereas pollinators interacted with a median of 1 plant (range = 1-25). In Bluff Mesa I observed and recorded 1,947 plant-

pollinator visits in 2001, 1,439 visits in 2002 and 1,095 2003. Plants at Bluff Mesa interacted with medians of 5 pollinators in 2001 (range = 1-61), 5 in 2002 (range = 1-54), and 4 in 2003(range = 1-58). Pollinators at Bluff Mesa in turn interacted with medians of 2 in 2001 (range = 1-20), 1 in 2002 (range = 1-16) and 1 in 2003 (range = 1-19). When analyzed across all three years at Bluff Mesa plants interacted with a median of 7 pollinators (range 1-124) whereas pollinators interacted with a median of 2 plants (range = 1-34, Table 1.1).

Question 1) What is the distribution of links per species, and what does the distribution suggest about how plants and pollinators interact with each other?

Cumulative link distributions $P(k)$ were best fit by either power law or truncated power distributions for both plants and animals in Virginia Basin and Bluff Mesa (Table 1.2, Figure 1.1). The plant communities were always best fit by truncated power distributions. The Virginia Basin and the 2001 and 2001-2003 Bluff Mesa pollinator assemblages were also best fit by truncated power law distributions. However in 2001 and 2003 the Bluff Mesa pollinator assemblages fit power law distributions. These were the same two years in which the generalist bees *Apis mellifera* and *Bombus vosnesenskii* (Apidae) were the most abundant pollinator species in the community (Table 1.3).

Question 2) Are the plant and pollinator species from these two montane communities more specialized or generalized than expected by chance, and how does abundance influence the degree of generalization?

The observed distributions of the number of links per species, k , for plant and pollinator assemblages from Virginia Basin and Bluff Mesa all deviated significantly

from Vázquez and Aizen's (2003) model 1, suggesting that the number of specialists and generalists species was significantly higher than expected by chance (Table 1.4). This is not unexpected given that model 1 randomly assigns links to species. Model 2, which incorporates the frequency of observed interaction, f , when generating null communities, matched the empirical patterns slightly better than model 1, as measured by the smaller D-values. This suggests that species abundance influences the number of links a species makes, however estimates of abundance do not account for all the variation in the links per species in model 2; D-values still fall outside the upper and lower confidence limits for all the plant and pollinator assemblages, suggesting that generalist and specialist species are more common than expected (Table 1.4). Nevertheless k and f values for the plant and pollinator assemblages are positively correlated with each other (Table 1.5). The number of links per plant k_p , were also positively correlated with direct estimates of floral abundance, but not as strongly as with f_p values (Table 1.5).

Question 3) Are these mutualistic communities significantly nested, and if so what species constitute the core of generalists?

Plant-pollinator communities in Virginia Basin and Bluff Mesa are significantly nested (Table 1.6). Nestedness values for the communities ranged from 0.9525-0.9769. The nestedness pattern is evident by visual inspection of Figure 1.2. The networks are dominated by generalist-generalist interactions with asymmetrical generalist-specialist interactions at the tails of the distribution. I identified the extreme generalists, or core group of plants and pollinators using k -core and *eigenvector centrality* routines (Table 1.7). Both techniques were in close agreement as to the identity of the most generalized

species. However, the number and identity of generalist species fluctuated extensively between years at Bluff Mesa, ranging from 14 to 28 species. The generalist pollinators at Bluff Mesa included fly, beetle, wasp, and bee species, whereas all the generalist pollinators from Virginia Basin were dipterans (Table 1.7).

4) Are there compartments with specialized plant and pollinator species embedded within the interaction network?

For all of the plant-pollinator communities I detected relatively large mean niche overlap values and higher variation as compared to null model expectation, suggesting that these communities are highly structured and that compartments might be present (Table 1.8). The *components* routine was successful in identifying a small number of compartments with specialized plant and pollinator species that interacted frequently with one another (Table 1.9). In Bluff Mesa the identity of the species involved in compartments fluctuated between years, with one exception, *Castilleja miniata* (Scrophulariaceae), which was visited frequently by 2 hummingbird species, *Selasphorus rufus* and *Stellula calliope*. The other common specialist pollinator was *Hyles lineata* (Sphingidae), which was common in 2 out of the 3 years but visited different plant species.

Discussion

The Virginia Basin and Bluff Mesa plant-pollinator communities had comparable structural and topological properties, and these resemble those reported recently from other community level surveys of mutualisms (e.g. Bascompte et al 2003, Jordano et al.

2003, Dupont et al 2003). For the most part, plant and pollinator species interacted with generalist partners; reciprocally specialized interactions were relatively rare. The link distributions for the plant and animal assemblages were best fit by power and truncated power law distributions. Such assemblages are characterized by a continuous distribution of links per species, with many species interacting with relatively few partners, and fewer generalist species that interact with several partners (Jordano et al. 2003). Thus there is no single value, such as the mean or median number of links per species, that adequately describes the degree of generalization for these assemblages, or the number of species that a typical member in the community interacts with. However the shapes of the link distributions does suggest that plants and pollinators do not interact randomly with each other. Analysis of abiotic and biotic systems suggest that interaction networks that fit power laws have nodes that establish links to one another in proportion to the links that they already possess (Barabási and Albert 1999). Here the link distributions suggest that plant and pollinator species preferentially interact with some species, namely generalists (Barabási and Albert 1999, Jordano et al. 2003).

It is likely that species abundance is the major factor influencing the degree of generalization; the more abundant a species is the great opportunity it has to interact with other mutualistic species (Dupont et al. 2003, Vázquez and Aizen 2003). This idea is supported by the positive correlations between the frequency of observed interaction and the number of links per species, as well as the results of Vázquez and Aizen's null models. The influence of abundance on the number of links per species is also evident when one examines the super-generalist bee species *Apis mellifera* and *Bombus*

vosnesenskii. During the summers of 2001 and 2003, when both bee species were extremely common at Bluff Mesa, I observed both of them to interact with approximately half of the plant species in the community. However in 2002 when *Apis mellifera* was relatively rare and *Bombus vosnesenskii*'s population was only half as large as in the other years, both species were observed to interact with fewer plant species, typically the most abundant plant species. It is possible that the association between the number of links per species and abundance might be due to sampling artifacts (Vázquez and Aizen 2003, Memmott et al. submitted), but it is unlikely that I would have missed floral visits by large and conspicuous pollinators such as bumblebees and honeybees during the summer of 2002 in an open meadow. What this might suggest then is that visitation patterns truly reflect diet breadth, and that pollinators prefer to utilize the most abundant floral resources available within the community.

The distribution of links per species is also consistent with the finding that these plant-pollinator communities are highly nested, meaning that each species typically interacts with a subset of species that the next most generalized species interacts with. Nested communities is also characterized by a lack of pronounced compartments and a dominance of generalist-generalist and asymmetric interactions, in which those with few partners interact with generalist species, as has been well documented in several other plant-pollinator communities (Petanidou and Vokou 1993, Petanidou and Ellis 1996, Bascompte et al. 2003, Ollerton et al. 2003, Vázquez and Aizen 2004, Memmott et al. submitted).

With the aid of novel techniques it is also rather easy to identify the core group of generalist species that most other species interact with. The most generalized plant species in both communities were numerically abundant, but also possessed relatively open and simple floral morphologies that were accessible to most floral visitors. However, the groups of generalist pollinators were very different between the two meadow communities. In Virginia Basin dipterans were the dominant group of floral visitors. At higher elevations the abundance of most insects groups tends to decline, except for flies, thus they are relatively more abundant and interact with most plant species (Kearns 1992). In contrast at Bluff Mesa the generalist pollinators were taxonomically diverse, but the species composition varied substantially between years. Although pollinator populations might fluctuate extensively between years, plant populations are likely to be tolerant of such variation due to the redundancy in pollination services (Bascompte et al. 2003, Jordano et al. 2003, Memmott et al., submitted).

Perfect nestedness, however, is never achieved; presumably mismatches between plant and pollinator morphology and phenology impose restrictions as to which species actually interact (Bascompte et al. 2003, Jordano et al. 2003). This creates the opportunity for relatively specialized plant-pollinator relationships to persist within these communities as somewhat isolated compartments. In both Virginia Basin and Bluff Mesa compartments were present, but they were rare. Some of the compartments appear to coincide with pollination syndromes in that the specialized plant species possess floral characteristics that “match” the pollinators that visited them. In Virginia Basin I identified compartments that matched the hummingbird and bumblebee syndrome. At

Bluff Mesa in I identified compartments that fit the hummingbird, butterfly and hawkmoth syndromes, however only the hummingbird compartment was detected across all three years of the study. Hawkmoths (*Hyles lineata*, Sphingidae) were also found to be members of a compartments in two years, but they specialized on different plant species each year: *Lilium parryi* (Liliaceae) in 2001 and *Penstemon caesius* (Scrophulariaceae) in 2003. However, the variation in the hawkmoth specialization is most likely due to changes to my sampling method; in 2002 and 2003 I did not record nocturnal pollinator visits, which is when they were typically observed to visit *Lilium parryi* flowers. However hawkmoths were never observed to interact with any other plant species in the community, which suggests that they have a narrow niche breadth and are limited to visit flowers with wide corollas. Interestingly, the rufous hummingbird, *Selasphorus rufus*, specialized on *Castilleja miniata* (Scrophulariaceae) in both Virginia Basin and Bluff Mesa, suggesting that perhaps interactions with hummingbirds might be ecologically stable across space.

In addition to describing the structure and topology of plant-pollinator communities, network analyses can help conservation biologists identify how introduced species are interacting with other species in the community (Memmott and Waser 2002). Large populations of feral *Apis mellifera* are of particular concern in natural systems because they can suppress native plant and pollinator populations by usurping floral resources and reducing effective pollen transfer (Buchmann and Nabhan 1996). In Bluff Mesa, honeybees were the most abundant pollinator species in 2001 and 2003, and visited nearly half of the plant species in the community, thus directly or indirectly

interacting with most of the plants and pollinators in the community. In habitats where invasive species interact with a large fraction of the community, and thus threaten to influence the entire community, their management becomes an especially high priority.

The patterns presented here support the view that plant-pollinator communities are dominated by interactions with generalist species and that reciprocally specialized relationships are relatively rare. This study also highlights the annual variability in plant-pollinator interactions, with the core group of generalist pollinator species changing between years as well as the species in specialized compartments. It is likely that most populations will interact with different mutualist partners in across years and sites because of this variation in community composition and redundancy in services provided. Given the structure and variability of these plant-pollinator communities it appears that the ecological conditions required for pollinator mediated selection to take place under the traditional view of floral evolution would rarely be met for most plant species in most years, except for perhaps those species that interact with some what spatially and temporally predictable species, such hummingbirds or hawkmoths. Further work however is necessary to document community level dynamics across longer time periods to see if the patterns described here are the norm, and if networks descriptions based on floral visitation reflect patterns of pollen removal and deposition. If the patterns presented here hold true, however, then biologists will have to reconsider the mechanisms and ecological conditions that permit the evolution of specialized floral morphologies (Aigner 2001).

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Table 1.1

Descriptive data for the Bluff Mesa and Virginia Basin plant-pollinator communities summarizing the total number of species, N; number of plant species, P; number of animal pollinator species, A; number of floral visits observed, V; number of plant-pollinator links, K; median number links per plant, $\langle k_p \rangle$; maximum number of links per plant, $k_{\max P}$; mean number of links per plant, $k_{\text{mean}P}$; standard deviation for the number of links per plant, $k_{\text{stdv}P}$; median frequency of visits to plants, $\langle f_p \rangle$; maximum frequency of visits to plants, $f_{\max P}$; mean frequency of visits to plant, $f_{\text{mean}P}$; standard deviation for the frequency of visits to plants, $f_{\text{stdv}P}$; median number links per pollinator, $\langle k_a \rangle$; maximum number of links per pollinator, $k_{\max A}$; mean number of links per pollinator, $k_{\text{mean}A}$; standard deviation for the number of links per plant, $k_{\text{stdv}A}$; median frequency of observed visits by pollinators, $\langle f_a \rangle$; maximum frequency of observed visits by pollinators, $f_{\max A}$; mean frequency of visits by pollinators, $f_{\text{mean}A}$; standard deviation for the frequency of visits by pollinators, $f_{\text{stdv}A}$.

Community	N	P	A	V	K	$\langle k_p \rangle$	$k_{\max P}$	$k_{\text{mean}P}$	$k_{\text{stdv}P}$	$\langle f_p \rangle$	$f_{\max P}$	$f_{\text{mean}P}$	$f_{\text{stdv}P}$
Bluff Mesa 2001	180	41	139	1947	388	5	60	9.46	13.08	18	351	47.49	83.03
Bluff Mesa 2002	198	47	151	1439	389	5	54	8.28	9.98	12	251	30.62	49.02
Bluff Mesa 2003	164	36	128	1095	293	4	58	8.14	10.91	14.5	190	30.42	44.05
Bluff Mesa 2001-2003	329	64	265	4481	870	7	123	13.60	19.20	19	763	70.02	130.80
Virginia Basin	177	41	136	2111	405	3	69	9.88	14.01	8	409	51.49	95.82

Community	$\langle k_a \rangle$	$k_{\max A}$	$k_{\text{mean}A}$	$k_{\text{stdv}A}$	$\langle f_a \rangle$	$f_{\max A}$	$f_{\text{mean}A}$	$f_{\text{stdv}A}$
Bluff Mesa 2001	2	20	2.79	3.11	2	373	12.73	40.19
Bluff Mesa 2002	1	16	2.58	2.90	2	138	9.53	22.83
Bluff Mesa 2003	1	19	2.29	2.52	2	225	8.55	27.81
Bluff Mesa 2001-2003	2	34	3.28	4.24	3	616	16.24	56.48
Virginia Basin	1	25	2.98	3.62	2	482	15.52	53.18

Table 1.2

Results for cumulative link distribution, $P(k)$, model fitting to: a) a power law, $P(k) \sim k^{-\gamma}$; b) a truncated power law, $P(k) \sim k^{-\gamma} \exp(-k/k_x)$; and c) an exponential, $P(k) \sim \exp(-\gamma k)$ models for plant and pollinator assemblages. Gamma exponents (γ) are for the best fitting model (see methods). K_x is the value of k where the truncated power distribution deviates from the power law distribution. Most assemblages are best fit by truncated and power law distributions.

Community	Plants				Pollinators			
	Model	Gamma	K_x	R^2	Model	Gamma	K_x	R^2
Bluff Mesa 2001	truncated	0.375	28.6	0.988	power	1.273	NA	0.994
Bluff Mesa 2002	truncated	0.345	19.56	0.973	truncated	0.545	5.22	0.978
Bluff Mesa 2003	truncated	0.432	27.58	0.950	power	1.542	NA	0.994
Bluff Mesa 2001-2003	truncated	0.361	41.24	0.952	truncated	0.930	19.75	0.991
Virginia Basin 2000	truncated	0.374	30.3	0.986	truncated	0.795	10.03	0.989

Table 1.3

Annual variation in the number of links to plant species (k_a) and the frequency of observed visits (f_a) for the three most common pollinator species at Bluff Mesa. *Apis mellifera* and *Bombus vosnesenskii* were the most abundant floral visitors in 2001 and 2003. In 2002 pollinator abundances were rather low and many species were not observed, including *Hyles lineata*.

Pollinator Species	2001		2002		2003	
	k_a	f_a	k_a	f_a	k_a	f_a
<i>Apis mellifera</i>	20	373	6	17	14	226
<i>Bombus vosnesenskii</i>	20	205	15	97	19	167
<i>Hyles lineata</i>	2	203	-	-	1	141

Table 1.4

Null model analysis comparing the observed number of links per species to null communities. Vázquez and Aizen's (2003) model 1 assumes that plant and pollinator species interact randomly each other when assigning links to generate the null interaction network, whereas model 2 assigns links between species in proportion to the frequency of observed interaction (see methods). The algorithm compares the observed distribution to the expected null frequencies by calculating the mean difference (D-value) between the data and 1000 null distributions. D-values falling outside the confidence limits suggest that the observed link distribution deviates from the null model at $p < 0.05$. In all cases the data deviate less from model 2 than model 1, suggesting that abundance influence the number of links per species. Statistically significant results are in boldface.

Plant Assemblage	Null Model 1			Null Model 2		
	Lower Limit	Upper Limit	D	Lower Limit	Upper Limit	D
Bluff Mesa 2001	5.69	20.47	46.73	11.36	24.90	32.05
Bluff Mesa 2002	5.79	21.37	48.46	10.57	24.76	29.75
Bluff Mesa 2003	4.63	18.61	43.91	8.16	21.28	27.73
Bluff Mesa 2001-2003	9.09	26.33	83.10	19.07	36.13	44.91
Virginia Basin 2000	5.78	20.09	61.09	11.90	25.82	30.89

Pollinator Assemblage	Null Model 1			Null Model 2		
	Lower Limit	Upper Limit	D	Lower Limit	Upper Limit	D
Bluff Mesa 2001	7.68	32.42	103.74	13.82	36.32	39.63
Bluff Mesa 2002	7.47	33.41	145.39	12.25	35.23	37.84
Bluff Mesa 2003	5.12	29.91	84.61	11.13	33.26	27.33
Bluff Mesa 2001-2003	12.61	49.52	234.12	25.89	58.97	80.13
Virginia Basin 2000	7.73	34.50	134.20	16.39	38.48	39.79

Table 1.5

Pearson correlations between the number of links per species (k) and the frequency of observed interaction (f) for plant and pollinator assemblages. Plant link (k_p) and interaction (f_p) distributions values are also compared to estimates of floral abundance.

**Correlations are significant at $p < 0.01$

*Correlations are significant at $p < 0.05$

Community	Plants $k_p - f_p$	Pollinators $k_a - f_a$	Floral Abundance $-k_p$	Floral Abundance $-f_p$
Bluff Mesa 2001	0.851**	0.757**	0.478**	0.448*
Bluff Mesa 2002	0.853**	0.820**	0.690**	0.668*
Bluff Mesa 2003	0.810**	0.704**	0.302*	0.217 ^{ns}
Bluff Mesa 2001-2003	0.870**	0.747**	0.474**	0.368*
Virginia Basin 2000	0.855**	0.885**	0.410*	0.405*

Table 1.6

Results for the nestedness community analyses. Nestedness range ranges from 0-1, with 1 being perfectly nested. Fill (connectance) is the fraction of potential plant-pollinator interactions actually observed. Significance was tested using the Nestedness Temperature Calculator's Monte Carlo procedure with 1000 trials (Atmar and Patterson 1995). Statistically significant results are in boldface ($p < 0.001$).

Community	Nestedness	Fill
Bluff Mesa 2001	0.9598	6.81%
Bluff Mesa 2002	0.9617	5.48%
Bluff Mesa 2003	0.9525	6.36%
Bluff Mesa 2001-2003	0.9699	5.13%
Virginia Basin 2000	0.9769	7.20%

Table 1.7

List of the most generalized plant and pollinator species as identified by the *k*-cores and *eigenvector centrality* routines (UCINET 6.0). The *k*-cores analysis identifies hierarchical groups of species based on the number of links each member shares with other members of the group. The group with the largest *k* value is typically composed of the most generalized species in the network. The *eigenvector centrality* routine ranks these species by calculating a score of how generalized each species that it interacts with is, such that species with high eigenvector values tend to interact with the more generalized species.

Bluff Mesa 2001, *k*-core degree = 6

Pollinators	Family	Rank and Eigenvalue	Plants	Family	Rank and Eigenvalue
<i>Apis mellifera</i>	Apidae	1) 27.412	<i>Achillea millefolium</i>	Asteraceae	1) 53.988
<i>Bombus vosnesenskii</i>	Apidae	2) 26.782	<i>Geranium richardsonii</i>	Geraniaceae	2) 46.782
Scaptiidae sp. 1	Scaptiidae	3) 23.198	<i>Sphenosciadium capitellatum</i>	Apiaceae	3) 35.843
Anthomyiidae sp. 2	Anthomyiidae	4) 23.082	<i>Potentilla glandulosa</i>	Rosaceae	4) 32.618
Anthomyiidae sp. 3	Anthomyiidae	6) 20.688	<i>Heracleum lanatum</i>	Apiaceae	5) 23.845
<i>Anthaxia sp. 1</i>	Buprestidae	8) 19.93	<i>Lupinus polyphyllus</i>	Fabaceae	6) 23.811
Staphylinidae sp. 1	Staphylinidae	9) 17.882	<i>Rosa californica</i>	Rosaceae	11) 11.296

Bluff Mesa 2002, *k*-core degree = 5

Pollinators	Family	Rank and Eigenvalue	Plants	Family	Rank and Eigenvalue
<i>Anthaxia sp. 1</i>	Buprestidae	1) 32.194	<i>Achillea millefolium</i>	Asteraceae	1) 59.053
<i>Bombus vosnesenskii</i>	Apidae	2) 25.076	<i>Calyptridium umbellatum</i>	Portulacaceae	2) 37.123
Melyridae sp. 5	Melyridae	3) 24.767	<i>Sphenosciadium capitellatum</i>	Apiaceae	3) 26.681
<i>Plebejus saepiolus</i>	Lycaenidae	4) 22.078	<i>Eriophyllum lanatum</i>	Asteraceae	4) 24.508
<i>Ammophila sp. 1</i>	Sphecidae	5) 21.18	<i>Lotus nevadensis</i>	Fabaceae	5) 23.523
<i>Megachile sp. 1</i>	Megachilidae	6) 21.124	<i>Potentilla glandulosa</i>	Rosaceae	6) 22.245
<i>Hemipenthes sp. 1</i>	Bombyliidae	7) 20.109	<i>Geranium richardsonii</i>	Geraniaceae	7) 21.392
<i>Lasioglossum sp. 2</i>	Halictidae	8) 18.608	<i>Lupinus latifolius</i>	Fabaceae	8) 20.285
<i>Hylaeus sp. 1</i>	Colletidae	9) 18.295	<i>Prunus virginiana</i>	Rosaceae	9) 17.33
Conopidae sp. 1	Conopidae	10) 18.032	<i>Erigeron divergens</i>	Asteraceae	10) 13.408
Nyssonidae sp. 1	Nyssonidae	11) 17.553	<i>Heracleum lanatum</i>	Apiaceae	11) 13.03
<i>Hylaeus sp. 2</i>	Colletidae	12) 17.131	<i>Roripa curvisiliqua</i>	Brassicaceae	12) 12.822
Scaptiidae sp. 1	Scaptiidae	20) 11.075			

Table 1.7 continued

Bluff Mesa 2003, k-core degree=4

Pollinators	Family	Rank and Eigenvalue	Plants	Family	Rank and Eigenvalue
<i>Bombus vosnesenskii</i>	Apidae	1) 33.506	<i>Achillea millefolium</i>	Asteraceae	1) 69.185
<i>Apis mellifera</i>	Apidae	2) 27.943	<i>Potentilla gracilis</i>	Rosaceae	2) 34.875
<i>Lasioglossum sp. 2</i>	Halictidae	3) 26.877	<i>Perideridia parishii</i>	Apiaceae	3) 31.2
<i>Eristalis sp. 2</i>	Syrphidae	4) 18.364	<i>Madia elegans</i>	Asteraceae	4) 23.408
<i>Melyridae sp. 5</i>	Melyridae	5) 17.813	<i>Sphenosciadium capitellatum</i>	Apiaceae	5) 20.863
<i>Bombylius sp. 1</i>	Bombyliidae	6) 17.672	<i>Calyptridium umbellatum</i>	Portulacaceae	6) 19.354
<i>Hylaeus sp. 1</i>	Colletidae	7) 17.225	<i>Aster occidentalis</i>	Asteraceae	7) 18.054
<i>Sphecidae sp. 1</i>	Sphecidae	8) 17.185	<i>Lupinus andersonii</i>	Fabaceae	8) 16.226
<i>Anthaxia sp. 1</i>	Buprestidae	9) 17.111	<i>Gayophytum diffusum</i>	Onagraceae	9) 13.51
<i>Eristalis sp. 1</i>	Syrphidae	10) 16.223	<i>Trifolium longipes</i>	Fabaceae	10) 12.048
<i>Scaptiidae sp. 1</i>	Scaptiidae	11) 15.115	<i>Sidalcea pedata</i>	Malvaceae	11) 11.989
<i>Nyssonidae sp. 1</i>	Nyssonidae	12) 15.093	<i>Ranunculus californicus</i>	Ranunculaceae	12) 10.237
<i>Ammophila sp. 1</i>	Sphecidae	13) 14.51			
<i>Villa sp. 2</i>	Bombyliidae	16) 13.197			
<i>Platycheirus stegnus</i>	Syrphidae	17) 12.899			

Bluff Mesa 2001-2003, k-core degree=7

Pollinators	Family	Rank and Eigenvalue	Plants	Family	Rank and Eigenvalue
<i>Bombus vosnesenskii</i>	Apidae	1) 26.389	<i>Achillea millefolium</i>	Asteraceae	1) 54.739
<i>Melyridae sp. 5</i>	Melyridae	2) 23.192	<i>Geranium richardsonii</i>	Geraniaceae	2) 32.993
<i>Apis mellifera</i>	Apidae	3) 22.842	<i>Sphenosciadium capitellatum</i>	Apiaceae	3) 31.644
<i>Anthaxia sp. 1</i>	Buprestidae	4) 22.559	<i>Potentilla glandulosa</i>	Rosaceae	4) 24.443
<i>Lasioglossum sp. 2</i>	Halictidae	5) 21.03	<i>Calyptridium umbellatum</i>	Portulacaceae	5) 20.099
<i>Hemipenthes sp. 1</i>	Bombyliidae	6) 21.026	<i>Perideridia parishii</i>	Apiaceae	6) 19.944
<i>Scaptiidae sp. 1</i>	Scaptiidae	7) 18.43	<i>Potentilla gracilis</i>	Rosaceae	7) 19.137
<i>Ammophila sp. 1</i>	Sphecidae	8) 15.418	<i>Heracleum lanatum</i>	Apiaceae	8) 18.536
<i>Anthomyiidae sp. 3</i>	Anthomyiidae	9) 15.298	<i>Eriophyllum lanatum</i>	Asteraceae	9) 17.93
<i>Plebejus saepiolus</i>	Lycaenidae	10) 15.18	<i>Lotus nevadensis</i>	Fabaceae	10) 16.08
<i>Hylaeus sp. 1</i>	Colletidae	11) 15.093	<i>Lupinus polyphyllus</i>	Fabaceae	11) 15.82
<i>Hylaeus sp. 2</i>	Colletidae	12) 13.829	<i>Aster occidentalis</i>	Asteraceae	12) 15.226
<i>Anthomyiidae sp. 2</i>	Anthomyiidae	13) 13.696	<i>Erigeron divergens</i>	Asteraceae	13) 14.584
<i>Megachile sp. 1</i>	Megachilidae	14) 13.562	<i>Madia elegans</i>	Asteraceae	14) 12.898
<i>Staphylinidae sp. 1</i>	Staphylinidae	15) 12.76	<i>Erysimum capitatum</i>	Brassicaceae	15) 12.376
<i>Nyssonidae sp. 1</i>	Nyssonidae	16) 12.004	<i>Lupinus andersonii</i>	Fabaceae	16) 11.925
<i>Conopidae sp. 1</i>	Conopidae	18) 11.166	<i>Prunus virginiana</i>	Rosaceae	17) 11.614
<i>Bombylius sp. 1</i>	Bombyliidae	20) 10.388	<i>Lupinus latifolius</i>	Fabaceae	18) 11.326
<i>Lasioglossum sp. 1</i>	Halictidae	30) 8.595	<i>Trifolium longipes</i>	Fabaceae	20) 8.991
			<i>Rosa californica</i>	Rosaceae	21) 8.607

Table 1.7 continued

Virginia Basin 2000, k-core degree=7

Pollinators	Family	Rank and Eigenvalue	Plants	Family	Rank and Eigenvalue
Muscidae sp. 10	Muscidae	1) 32.239	<i>Ligusticum porteri</i>	Apiaceae	1) 43.759
Muscidae sp. 9	Muscidae	2) 29.346	<i>Potentilla sp.</i>	Rosaceae	2) 37.767
Anthomyiidae sp. 10	Anthomyiidae	3) 26.63	<i>Senecio crassulua</i>	Asteraceae	3) 34.171
Muscidae sp. 5	Muscidae	4) 24.328	<i>Pseudocymopterus montanus</i>	Apiaceae	4) 32.296
Sciomyzidae sp. 1	Sciomyzidae	5) 21.848	<i>Erigeron elatior</i>	Asteraceae	5) 32.1
Muscidae sp. 4	Muscidae	6) 21.153	<i>Geranium richardsonii</i>	Geraniaceae	6) 26.634
Anthomyiidae sp. 7	Anthomyiidae	7) 20.798	<i>Helianthella quinquenervis</i>	Asteraceae	7) 21.658
Muscidae sp. 8	Muscidae	8) 19.397	<i>Helenium hoopsii</i>	Asteraceae	8) 19.961
Anthomyiidae sp. 4	Anthomyiidae	9) 19.22			
Muscidae sp. 7	Muscidae	13) 14.002			

Table 1.8

Results for EcoSim's Niche Overlap analysis of plant and pollinator assemblages using null model RA3 (Winemiller and Pianka, 1990). Model RA3 retains niche breadth but randomizes the resources consumed when generating null values. Observed niche overlap values and variance are significantly higher than the mean niche overlap values and mean variance per 1000 randomizations by the null model, suggesting highly structured communities and the possible presence of compartments. Statistically significant results are in boldface ($p < 0.01$).

Plant Assemblage	Observed niche overlap	Mean null model niche overlap	Observed variance	Mean null model variance
Bluff Mesa 2001	0.0931	0.0172	0.0264	0.0033
Bluff Mesa 2002	0.0683	0.0174	0.0182	0.0029
Bluff Mesa 2003	0.0842	0.0179	0.0233	0.0036
Bluff Mesa 2001-2003	0.0759	0.0125	0.0157	0.0016
Virginia Basin 2000	0.1202	0.0178	0.0307	0.0033

Pollinator Assemblage	Observed niche overlap	Mean null model niche overlap	Observed variance	Mean null model variance
Bluff Mesa 2001	0.1304	0.0336	0.0511	0.0135
Bluff Mesa 2002	0.0954	0.0263	0.0528	0.0130
Bluff Mesa 2003	0.1259	0.0345	0.0604	0.0167
Bluff Mesa 2001-2003	0.1146	0.0225	0.0488	0.0086
Virginia Basin 2000	0.1916	0.0319	0.0970	0.0140

Table 1.9

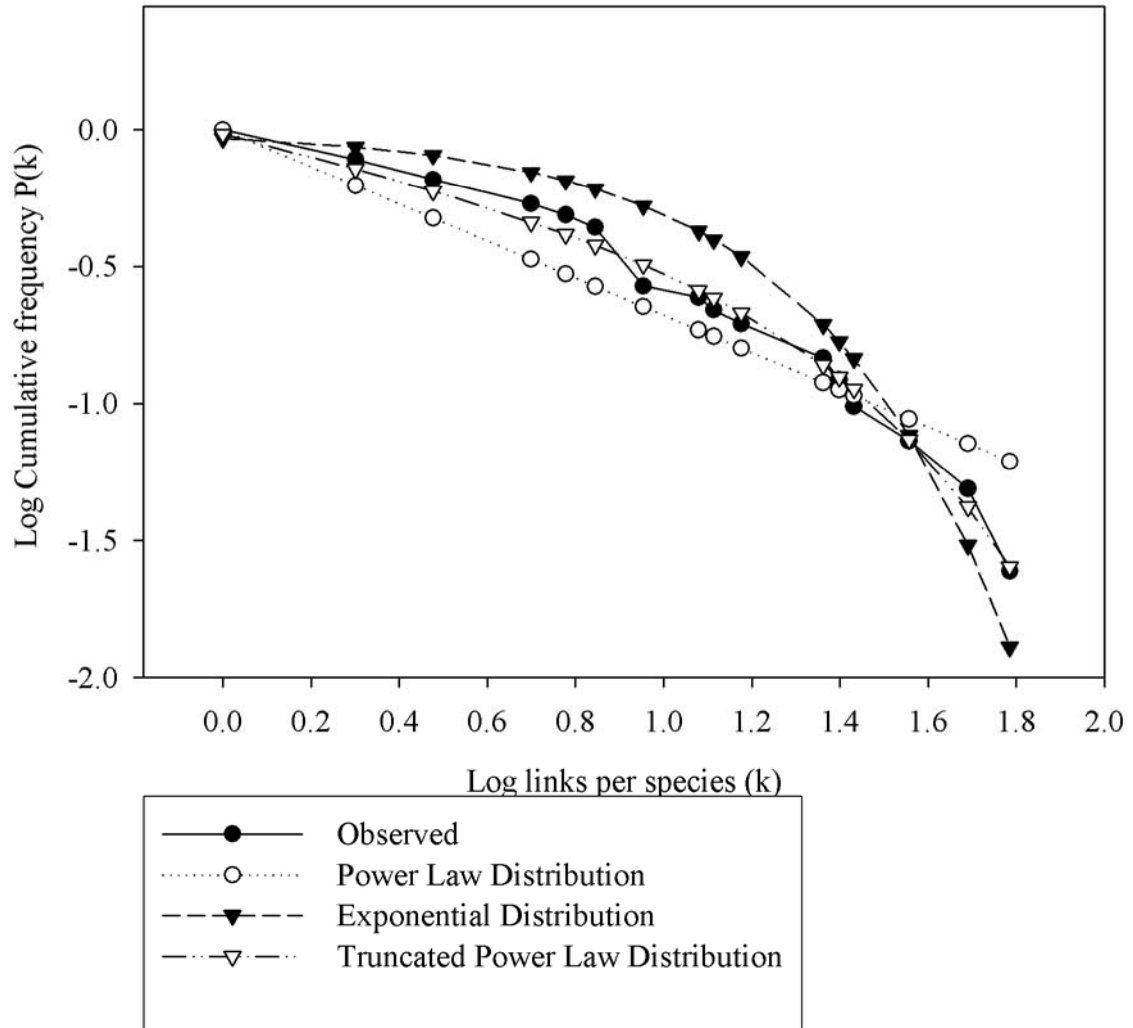
Specialized plant-pollinator compartments embedded within communities, as identified by the component routine in UCINET (6.0). This routine hierarchically clusters species (not shown) weighted by the number of times each pollinator species was observed to visit a plant species. Plant and pollinator species that interact frequently with one another are coupled together and are detached from species that they share few interactions with.

Bluff Mesa 2001				
Pollinator Species	Family	Plant Species	Family	Observed Visits
<i>Hyles lineata</i>	Sphingidae	<i>Lilium parryi</i>	Liliaceae	186
-	-	<i>Penstemon caesius</i>	Scrophulariaceae	17
<i>Selasphorus rufus</i>	Trochilidae	<i>Penstemon labrosus</i>	Scrophulariaceae	89
-	-	<i>Castilleja miniata</i>	Scrophulariaceae	21
<i>Stellula calliope</i>	Trochilidae	<i>Castilleja miniata</i>	-	11
<i>Papilio rutulus</i>	Papilionidae	<i>Erysimum capitatum</i>	Brassicaceae	12
-	-	<i>Plantanthera leucostachys</i>	Orchidaceae	11
-	-	<i>Aquilegia formosa</i>	Ranunculaceae	8
<i>Volucella mexicana</i>	Syrphidae	<i>Symphoricarpos rotundifolius</i>	Caprifoliaceae	8
Bluff Mesa 2002				
Pollinator Species	Family	Plant Species	Family	Observed Visits
<i>Selasphorus rufus</i>	Trochilidae	<i>Castilleja miniata</i>	Scrophulariaceae	49
Braconidae sp. 1	Braconidae	<i>Lepidium virginicum</i>	Brassicaceae	31
Bluff Mesa 2003				
Pollinator Species	Family	Plant Species	Family	Observed Visits
<i>Hyles lineata</i>	Sphingidae	<i>Penstemon caesius</i>	Scrophulariaceae	141
<i>Stellula calliope</i>	Trochilidae	<i>Penstemon labrosus</i>	Scrophulariaceae	23
-	-	<i>Castilleja miniata</i>	Scrophulariaceae	15

Table 1.9 continued

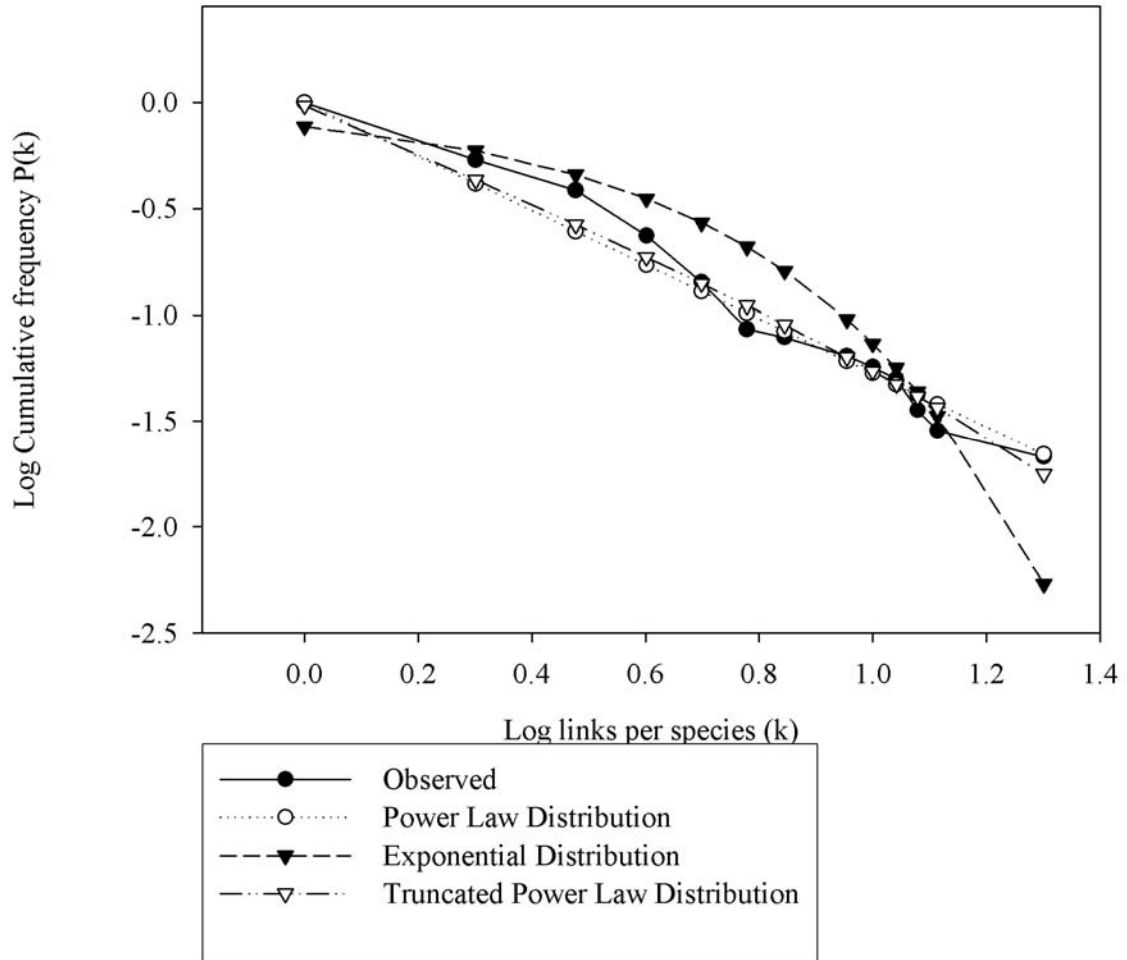
Bluff Mesa 2001-2003				
Pollinator Species	Family	Plant Species	Family	Observed Visits
<i>Hyles lineata</i>	Sphingidae	<i>Lilium parryi</i>	Liliaceae	186
		<i>Penstemon caesius</i>	Scrophulariaceae	156
<i>Papilio rutulus</i>	Papilionidae	<i>Erysimum capitatum</i>	Brassicaceae	16
-	-	<i>Plantanthera leucostachys</i>	Orchidaceae	12
-	-	<i>Aquilegia formosa</i>	Ranunculaceae	9
Braconidae sp. 1	Braconidae	<i>Lepidium virginicum</i>	Brassicaceae	31
<i>Selasphorus rufus</i>	Trochilidae	<i>Penstemon labrosus</i>	Scrophulariaceae	89
-	-	<i>Castilleja miniata</i>	Scrophulariaceae	70
<i>Stellula calliope</i>	Trochilidae	<i>Castilleja miniata</i>	-	31
<i>Volucella mexicana</i>	Syrphidae	<i>Symphoricarpos rotundifolius</i>	Caprifoliaceae	9
<i>Sphaerophora sp. 2</i>	Syrphidae	<i>Cryptantha affinis</i>	Boraginaceae	4
Virginia Basin 2000				
Pollinator Species	Family	Plant Species	Family	Observed Visits
<i>Selasphorus platycercus</i>	Trochilidae	<i>Castilleja miniata</i>	Scrophulariaceae	170
<i>Selasphorus rufus</i>	Trochilidae	<i>Castilleja miniata</i> -	-	26
<i>Bombus bifarius</i>	Apidae	<i>Chrysopsis villosa</i>	Asteraceae	20

Figure 1.1a



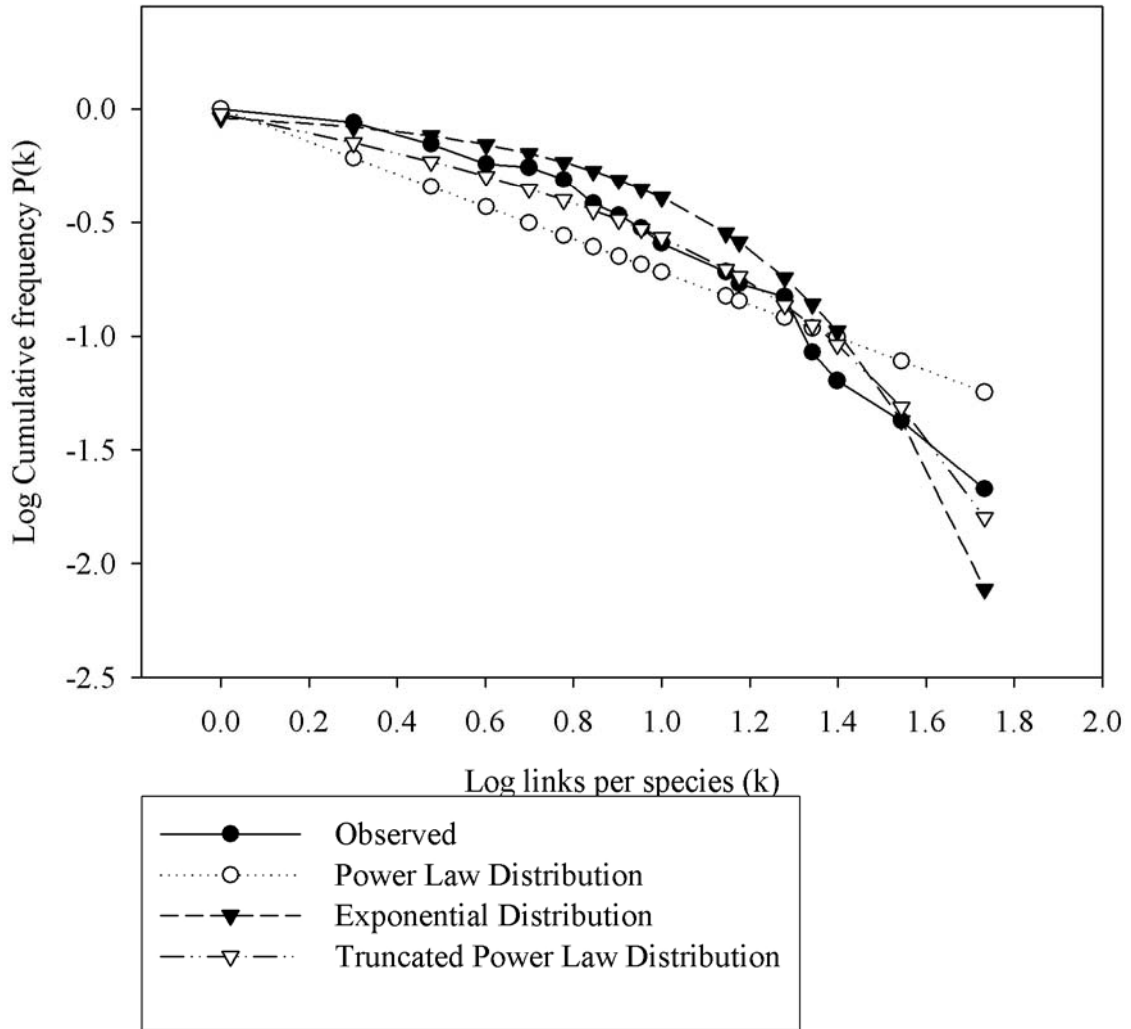
Cumulative link distribution, $P(k)$ vs. k (log-log scale), for the 2001 Bluff Mesa plant assemblage fitted to: a) a power law, $P(k) \sim k^{-\gamma}$; b) a truncated power law, $P(k) \sim k^{-\gamma} \exp(-k/k_x)$; and c) an exponential, $P(k) \sim \exp(-\gamma k)$ distribution. The observed distribution was best fit by a truncated power law (see methods and Table 1.5).

Figure 1.1b



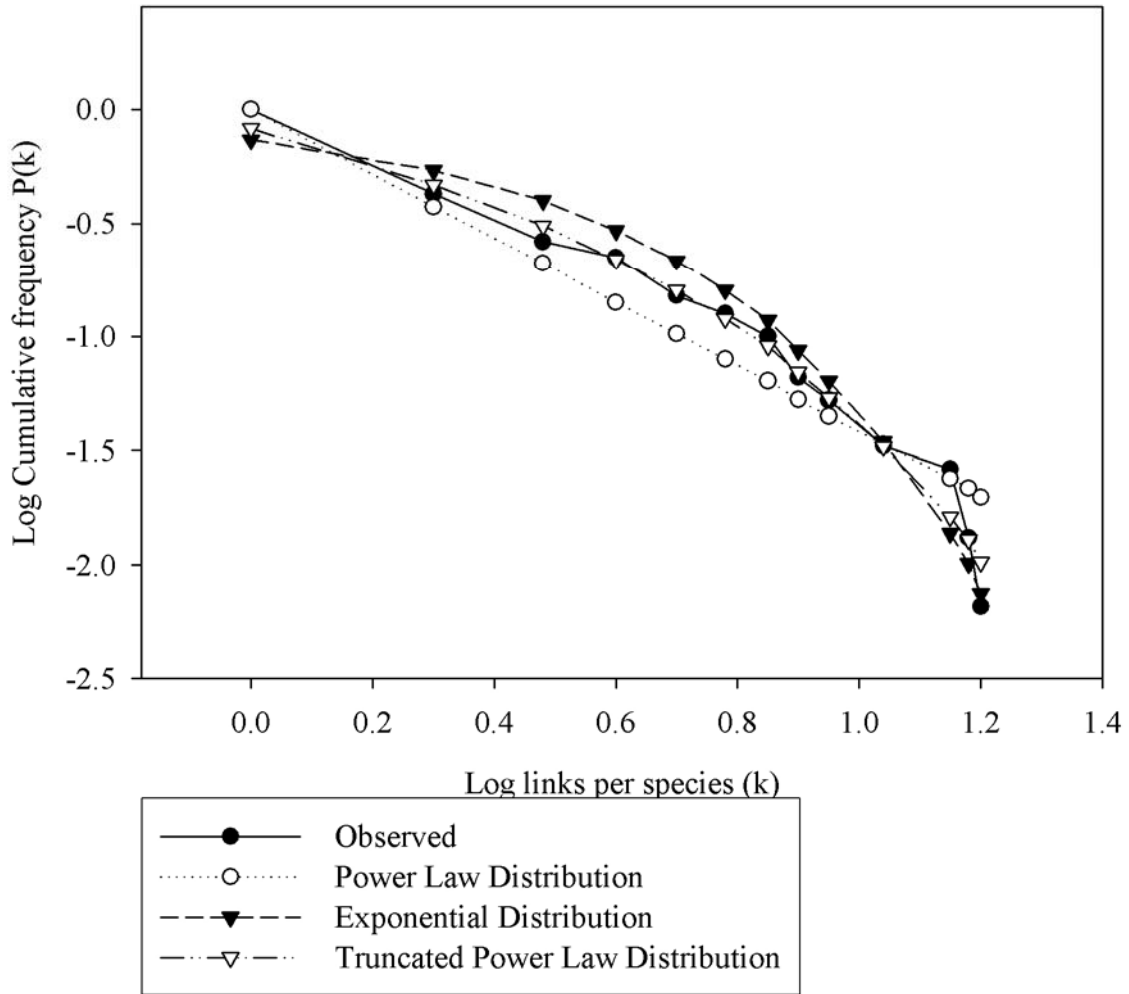
Cumulative link distribution, $P(k)$ vs. k (log-log scale), for the 2001 Bluff Mesa pollinator assemblage fitted to: a) a power law, $P(k) \sim k^{-\gamma}$; b) a truncated power law, $P(k) \sim k^{-\gamma} \exp(-k/k_x)$; and c) an exponential, $P(k) \sim \exp(-\gamma k)$ distribution. The observed distribution was best fit by a power law distribution (see methods and Table 1.5).

Figure 1.1c



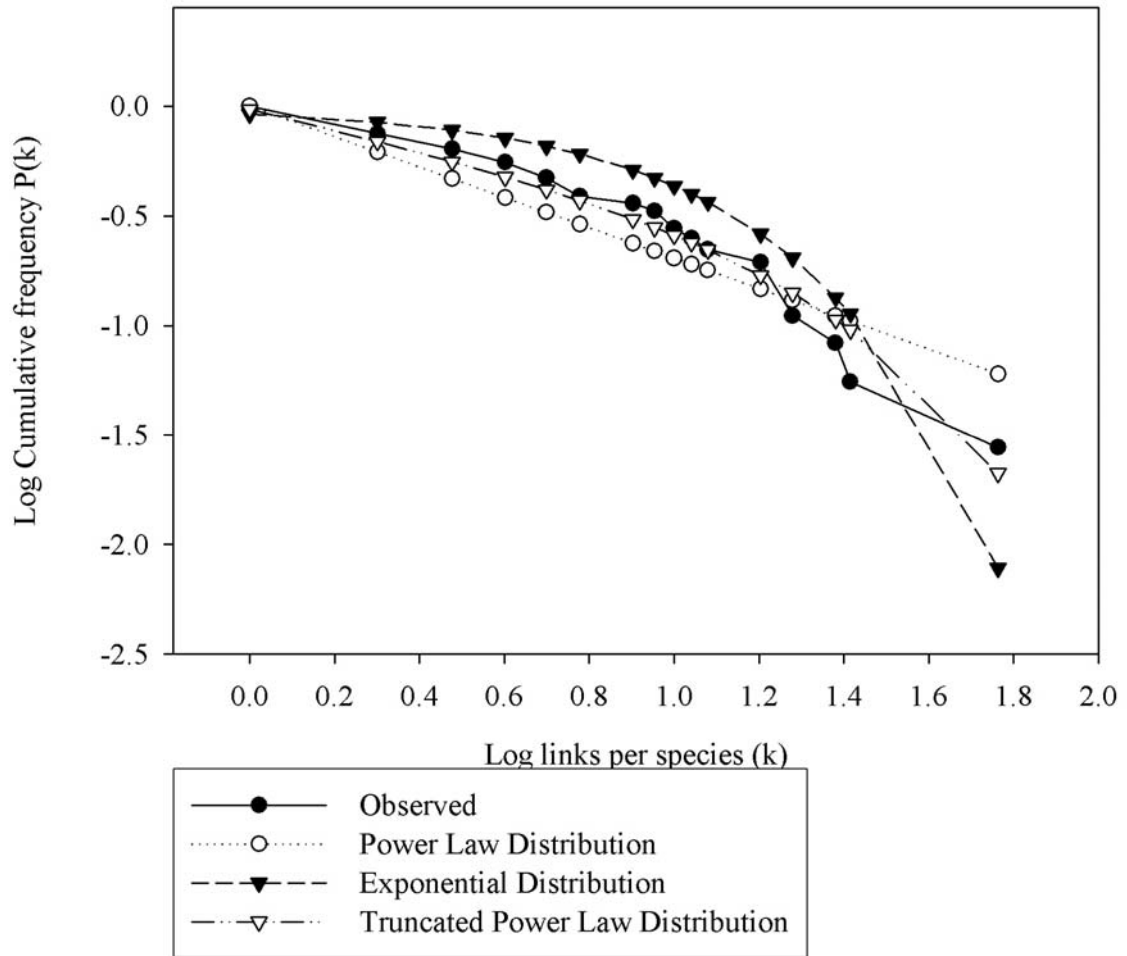
Cumulative link distribution, $P(k)$ vs. k (log-log scale), for the 2002 Bluff Mesa plant assemblage fitted to: a) a power law, $P(k) \sim k^{-\gamma}$; b) a truncated power law, $P(k) \sim k^{-\gamma} \exp(-k/k_x)$; and c) an exponential, $P(k) \sim \exp(-\gamma k)$ distribution. The observed distribution was best fit by a truncated power law (see methods and Table 1.5).

Figure 1.1d



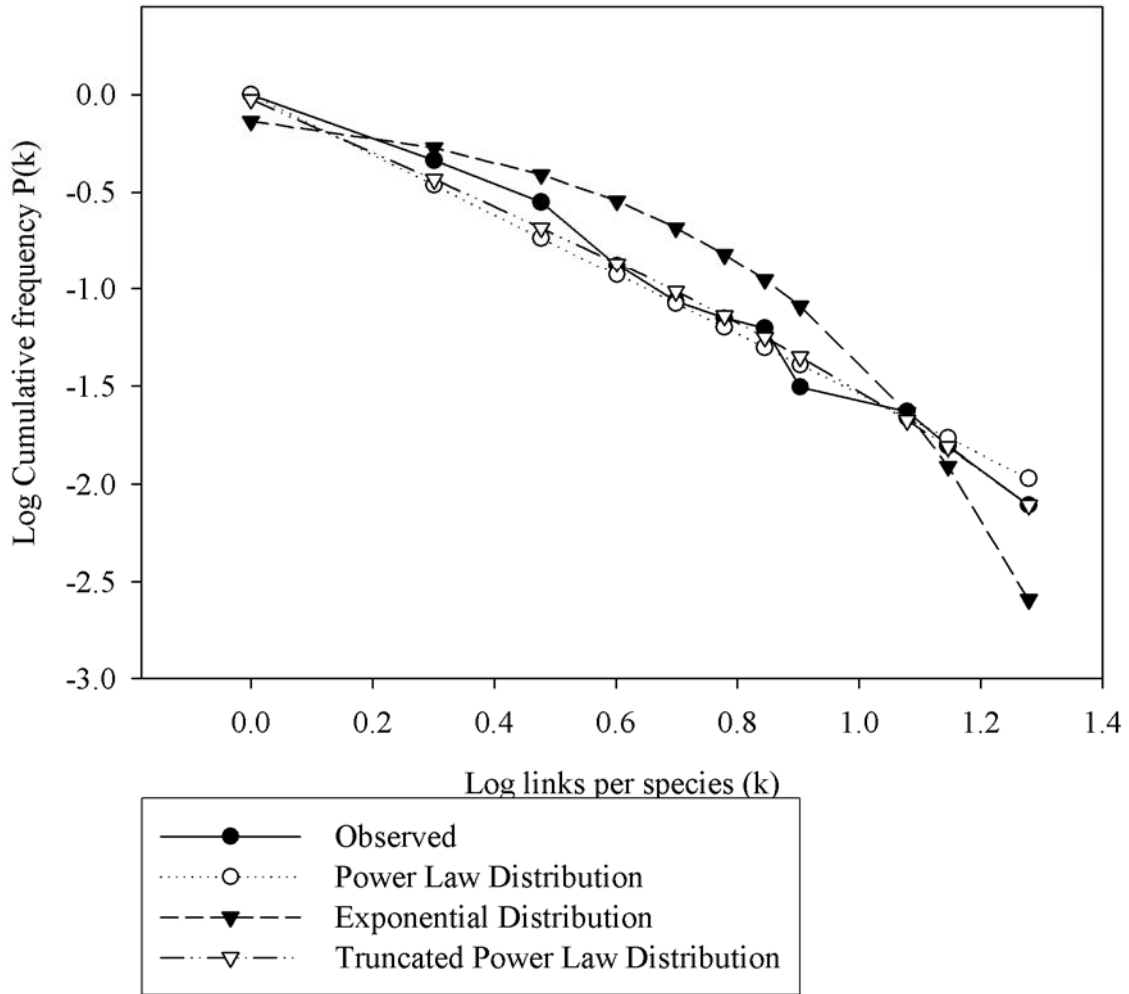
Cumulative link distribution, $P(k)$ vs. k (log-log scale), for the 200 Bluff Mesa pollinator assemblage fitted to: a) a power law, $P(k) \sim k^{-\gamma}$; b) a truncated power law, $P(k) \sim k^{-\gamma} \exp(-k/k_x)$; and c) an exponential, $P(k) \sim \exp(-\gamma k)$ distribution. The observed distribution was best fit by a truncated power law (see methods and Table 1.5).

Figure 1.1e



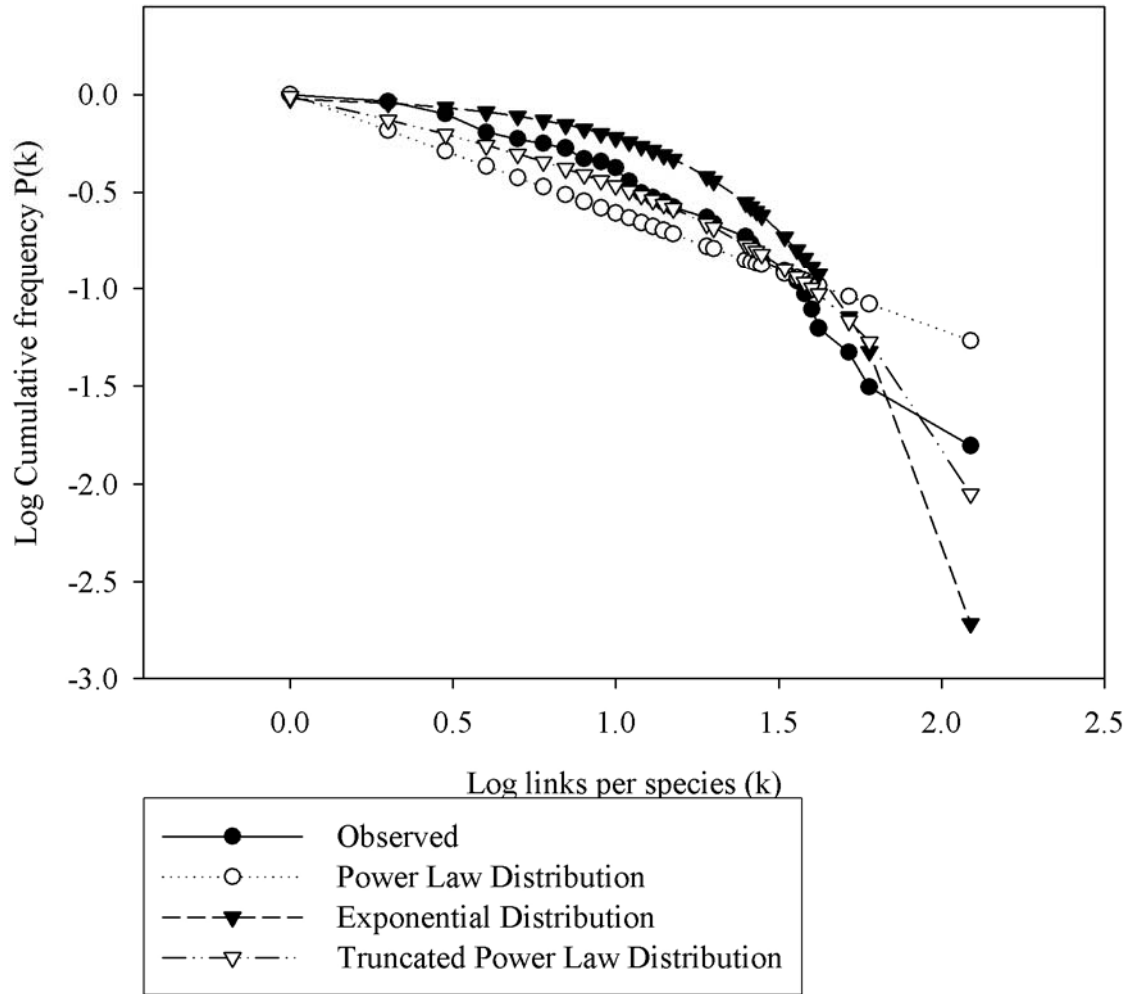
Cumulative link distribution, $P(k)$ vs. k (log-log scale), for the 2003 Bluff Mesa plant assemblage fitted to: a) a power law, $P(k) \sim k^{-\gamma}$; b) a truncated power law, $P(k) \sim k^{-\gamma} \exp(-k/k_x)$; and c) an exponential, $P(k) \sim \exp(-\gamma k)$ distribution. The observed distribution was best fit by a truncated power law (see methods and Table 1.5).

Figure 1.1f



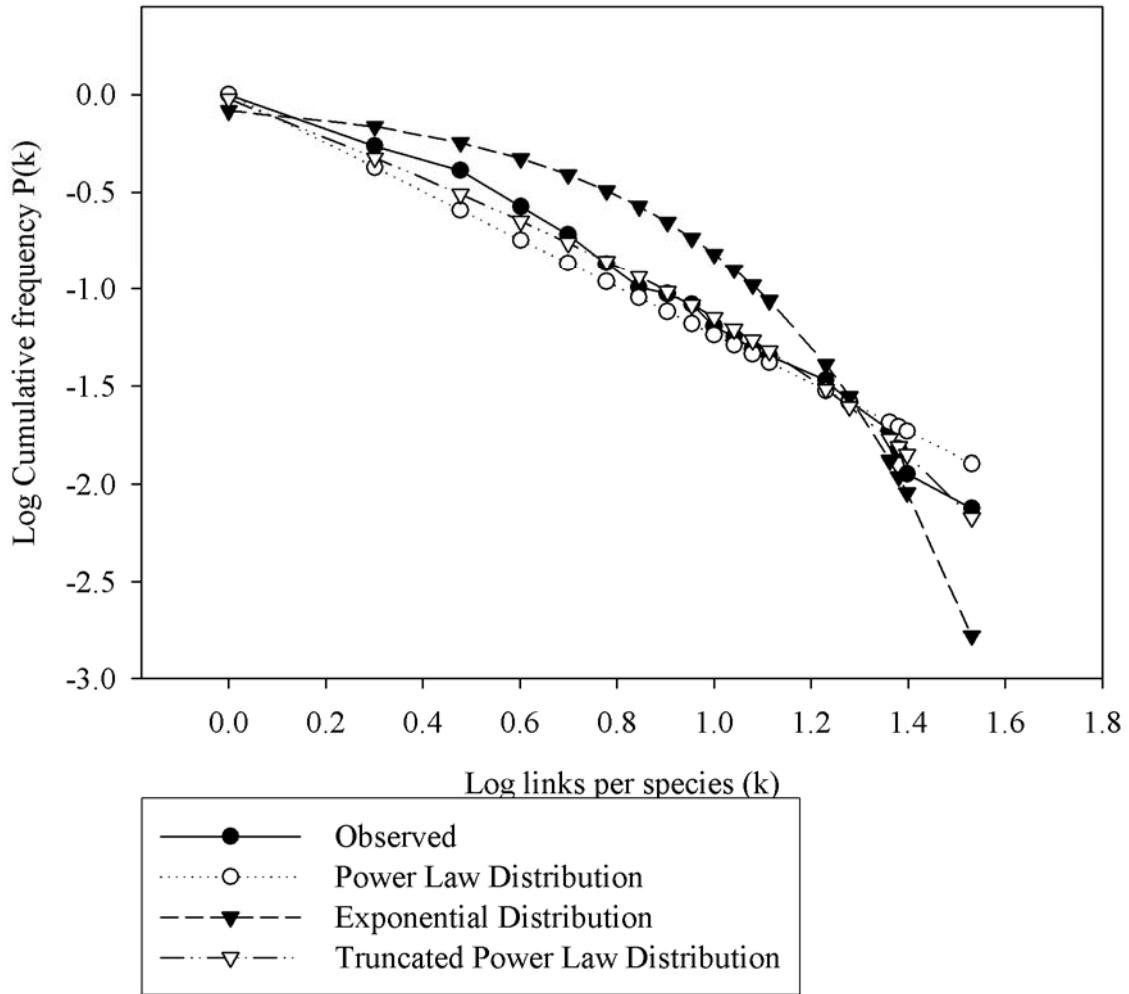
Cumulative link distribution, $P(k)$ vs. k (log-log scale), for the 2001 Bluff Mesa plant assemblage fitted to: a) a power law, $P(k) \sim k^{-\gamma}$; b) a truncated power law, $P(k) \sim k^{-\gamma} \exp(-k/k_x)$; and c) an exponential, $P(k) \sim \exp(-\gamma k)$ distribution. The observed distribution was best fit by a power law distribution (see methods and Table 1.5).

Figure 1.1g



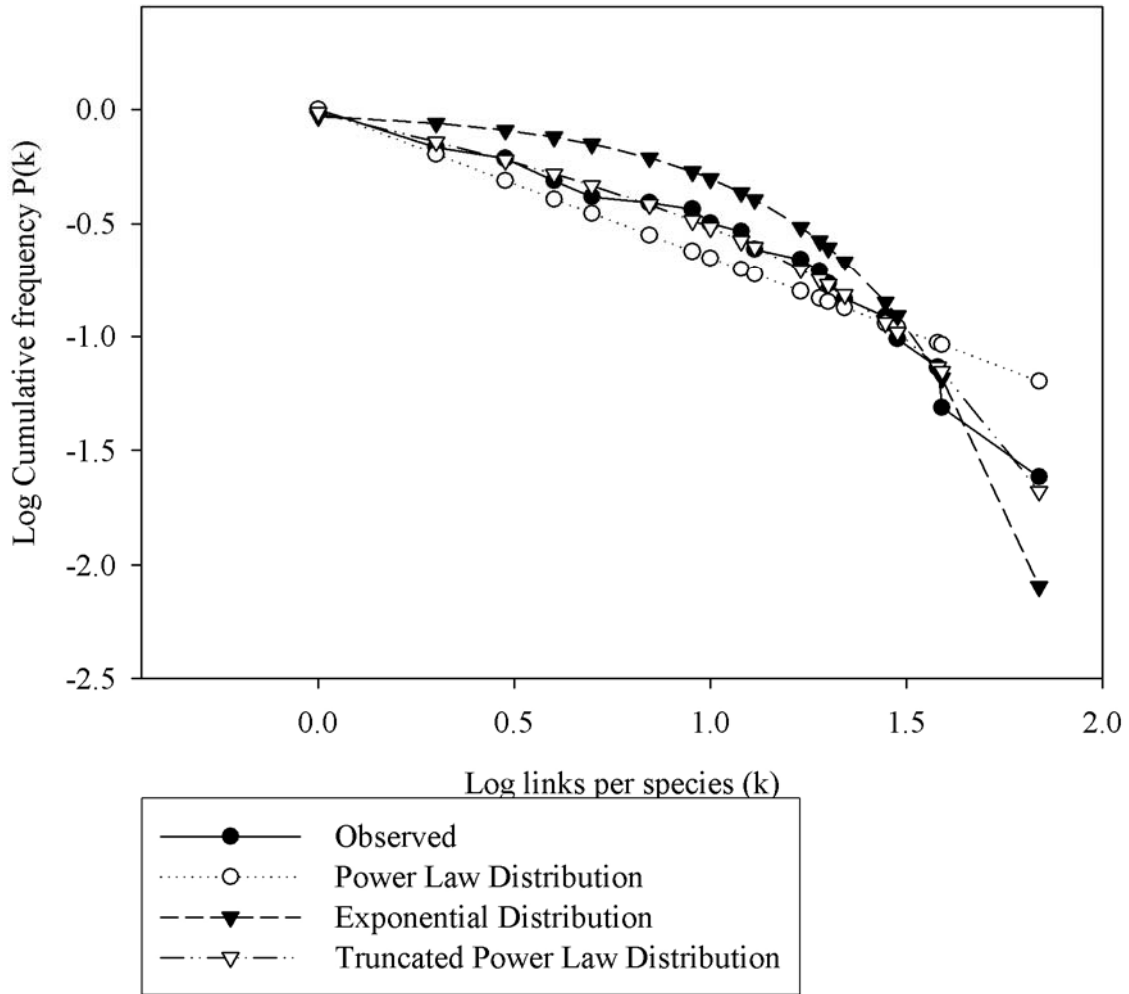
Cumulative link distribution, $P(k)$ vs. k (log-log scale), for the 2001-2003 Bluff Mesa plant assemblage fitted to: a) a power law, $P(k) \sim k^{-\gamma}$; b) a truncated power law, $P(k) \sim k^{-\gamma} \exp(-k/k_x)$; and c) an exponential, $P(k) \sim \exp(-\gamma k)$ distribution. The observed distribution was best fit by a truncated power law (see methods and Table 1.5).

Figure 1.1 h



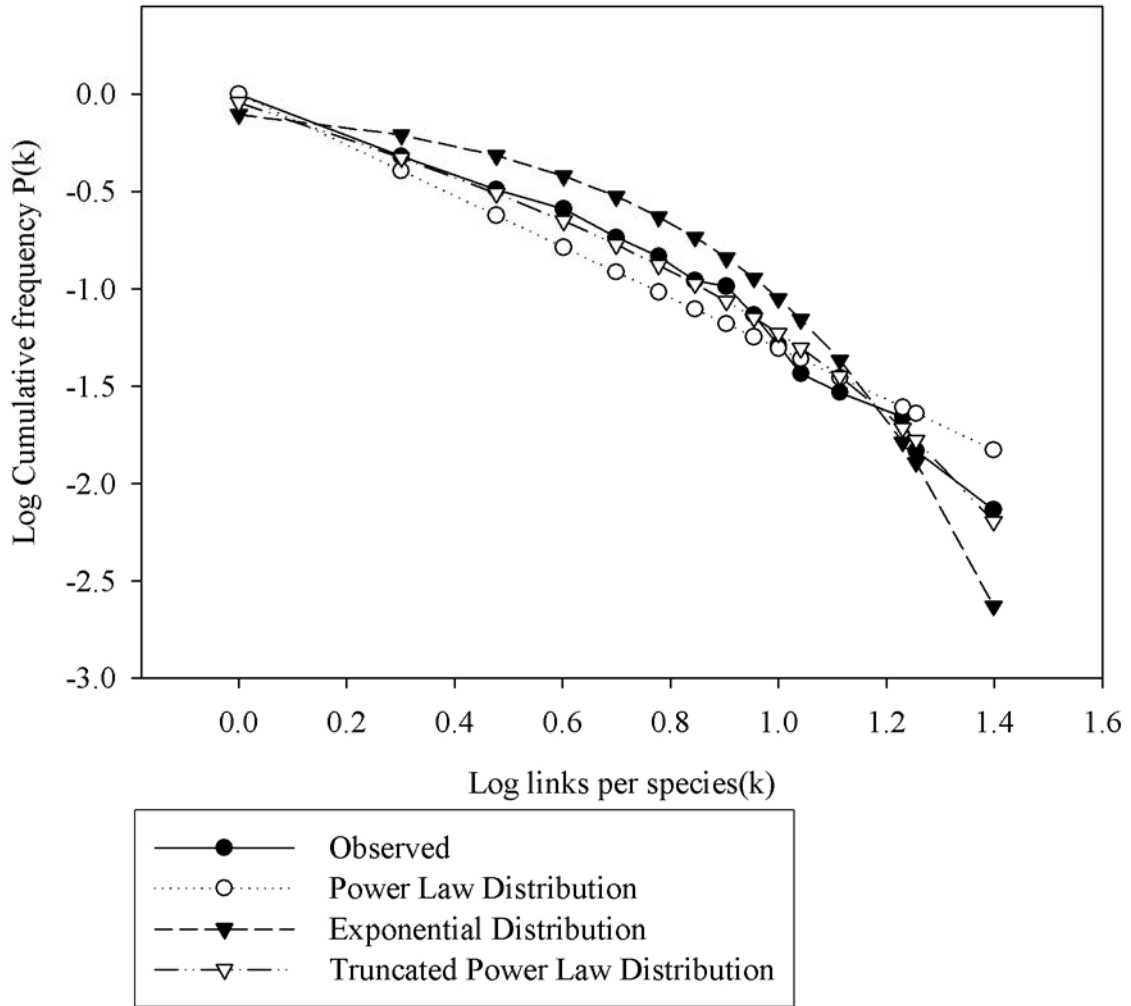
Cumulative link distribution, $P(k)$ vs. k (log-log scale), for the 2001-2003 Bluff Mesa pollinator assemblage fitted to: a) a power law, $P(k) \sim k^{-\gamma}$; b) a truncated power law, $P(k) \sim k^{-\gamma} \exp(-k/k_x)$; and c) an exponential, $P(k) \sim \exp(-\gamma k)$ distribution. The observed distribution was best fit by a truncated power law (see methods and Table 1.5).

Figure 1.1 i



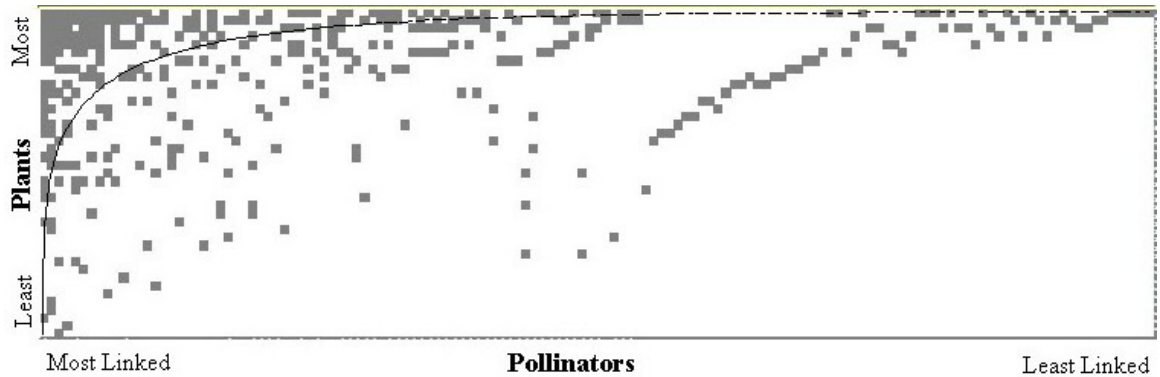
Cumulative link distribution, $P(k)$ vs. k (log-log scale), for the 2000 Virginia Basin plant assemblage fitted to: a) a power law, $P(k) \sim k^{-\gamma}$; b) a truncated power law, $P(k) \sim k^{-\gamma} \exp(-k/k_x)$; and c) an exponential, $P(k) \sim \exp(-\gamma k)$ distribution. The observed distribution was best fit by a truncated power law (see methods and Table 1.5).

Figure 1.1j



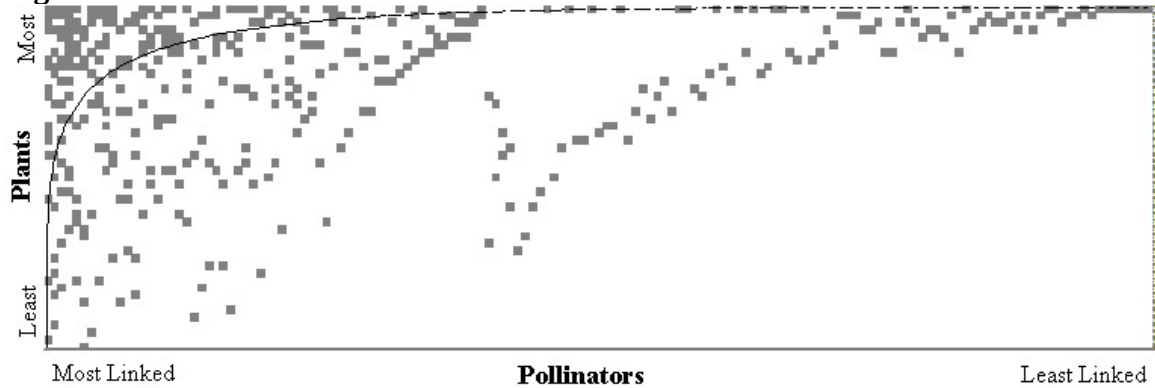
Cumulative link distribution, $P(k)$ vs. k (log-log scale), for the 2000 Virginia Basin pollinator assemblage fitted to: a) a power law, $P(k) \sim k^{-\gamma}$; b) a truncated power law, $P(k) \sim k^{-\gamma} \exp(-k/k_x)$; and c) an exponential, $P(k) \sim \exp(-\gamma k)$ distribution. The observed distribution was best fit by a truncated power law (see methods and Table 1.5).

Figure 1.2a



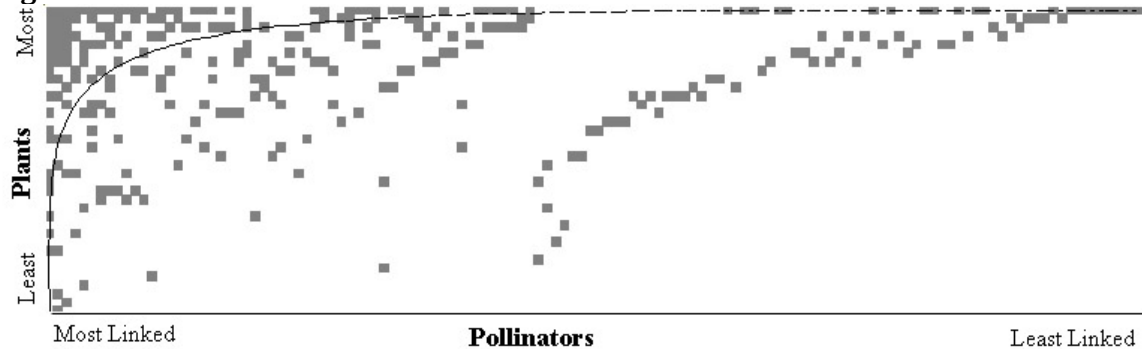
Graph for the 2001 Bluff Mesa plant-pollinator interaction network, maximally packed to depict the nested community structure. Pollinators are along the x-axis and arranged from most to least linked, while plants along the y-axis arranged from most to least linked (top-bottom). Shaded squares indicate an observed interaction between plants and pollinator species. The line through the graph is an isocline; if all the points were to be above the curve the community would be perfectly nested. The upper-left-hand corner is composed of generalist-generalist interactions while asymmetrical interactions are at the tail end of the distribution. This community is highly nested and significantly (Nestedness Index = 0.9598, maximum value=1.0; see Table 1.6).

Figure 1.2b



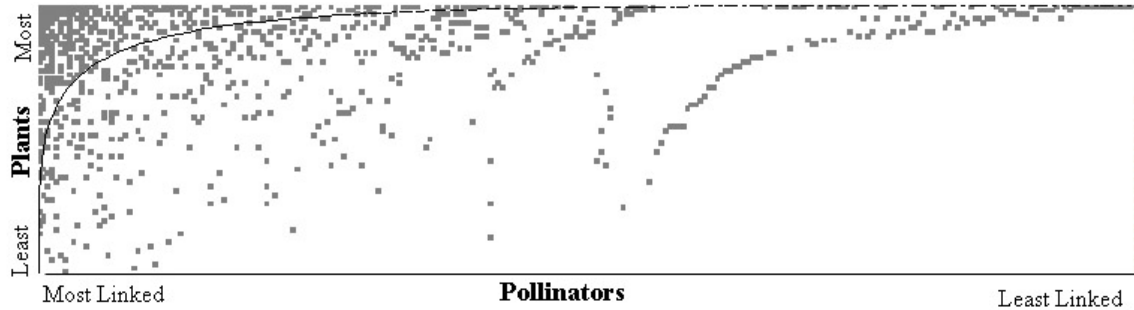
Graph for the 2002 Bluff Mesa plant-pollinator interaction network, maximally packed to depict the nested community structure. Pollinators are along the x-axis and arranged from most to least linked, while plants along the y-axis arranged from most to least linked (top-bottom). Shaded squares indicate an observed interaction between plants and pollinator species. The line through the graph is an isocline; if all the points were to be above the curve the community would be perfectly nested. The upper-left-hand corner is composed of generalist-generalist interactions while asymmetrical interactions are at the tail end of the distribution. This community is highly nested and significantly (Nestedness Index = 0.9617, maximum value=1.0; see Table 1.6).

Figure 1.2c



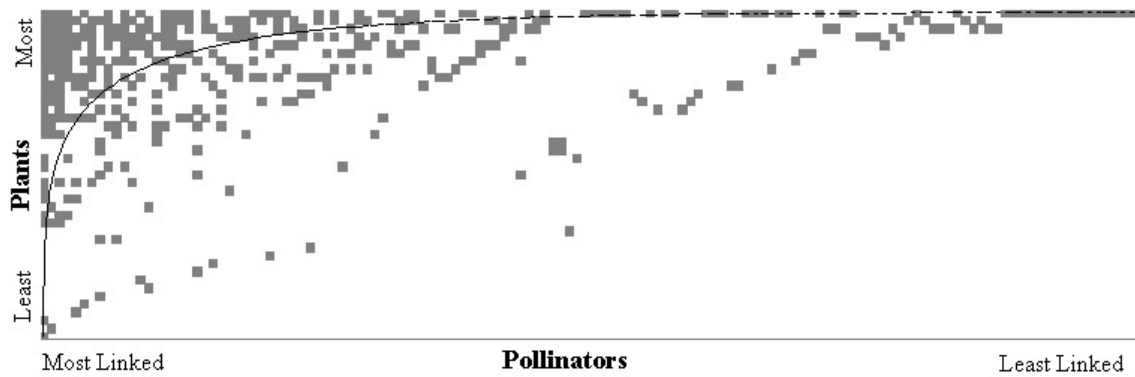
Graph for the 2003 Bluff Mesa plant-pollinator interaction network, maximally packed to depict the nested community structure. Pollinators are along the x-axis and arranged from most to least linked, while plants along the y-axis arranged from most to least linked (top-bottom). Shaded squares indicate an observed interaction between plants and pollinator species. The line through the graph is an isocline; if all the points were to be above the curve the community would be perfectly nested. The upper-left-hand corner is composed of generalist-generalist interactions while asymmetrical interactions are at the tail end of the distribution. This community is highly nested and significantly (Nestedness Index = 0.9525, maximum value=1.0; see Table 1.6).

Figure 1.2d



Graph for the 2001-2003 Bluff Mesa plant-pollinator interaction network, maximally packed to depict the nested community structure. Pollinators are along the x-axis and arranged from most to least linked, while plants along the y-axis arranged from most to least linked (top-bottom). Shaded squares indicate an observed interaction between plants and pollinator species. The line through the graph is an isocline; if all the points were to be above the curve the community would be perfectly nested. The upper-left-hand corner is composed of generalist-generalist interactions while asymmetrical interactions are at the tail end of the distribution. This community is highly nested and significantly (Nestedness Index = 0.9699, maximum value=1.0; see Table 1.6).

Figure 1.2e



Graph for the 2000 Virginia Basin plant-pollinator interaction network, maximally packed to depict the nested community structure. Pollinators are along the x-axis and arranged from most to least linked, while plants along the y-axis arranged from most to least linked (top-bottom). Shaded squares indicate an observed interaction between plants and pollinator species. The line through the graph is an isocline; if all the points were to be above the curve the community would be perfectly nested. The upper-left-hand corner is composed of generalist-generalist interactions while asymmetrical interactions are at the tail end of the distribution. This community is highly nested and significantly (Nestedness Index = 0.9769, maximum value=1.0; see Table 1.6).

CHAPTER 2

A TEST OF THE POLLINATION SYNDROME HYPOTHESIS: ARE SYNDROMES USEFUL FOR PREDICTING VISITATION PATTERNS IN A COMMUNITY CONTEXT?

Introduction

During the Nineteenth and Early Twentieth centuries biologists observed that flowers possessing a typical suite of traits, including color, scent and shape, appeared to be visited by a corresponding group of pollinators, typically at the level of family or order (e.g. Delpino 1868-1875; see Knuth 1906, Vogel 1954, Grant and Grant 1965, Faegri and van der Pijl 1966). This observation led to the *pollination syndrome hypothesis*, which postulates that particular trait combinations represent adaptations to attract and utilize specific pollinator taxa, often to the exclusion of other pollinators (Grant 1949, Grant and Grant 1965, Aigner 2001, Castellanos et al. 2004). The “classic” pollination syndromes include the bat, butterfly, beetle, carrion fly, bee, moth, hawkmoth, bird, fly, small mammal, and wasp syndromes; all of which have been described from several parts of the world (Ollerton and Watts 2000). For example, a typical “bird” flower is red, has a long corolla, and produces copious amounts of dilute nectar. The pollination syndrome hypothesis is an appealing idea because it seems to explain both floral diversification and the convergence of floral forms across angiosperms pollinated by similar pollinators. However, the ubiquity and predictive value of pollination syndromes still needs to be thoroughly tested.

Recently Wilson et al. (2004) searched for syndromes among *Penstemon* species and their close allies (Scrophulariaceae) and found that color was a good trait for distinguishing between species whose most common visitors were hummingbird versus bee or wasps. Changes in floral morphology that favored hummingbirds, such as narrowing of the corolla, were also found to simultaneously discourage bee pollination in

Penstemon flowers (Castellanos 2004). Results such as this suggest that floral traits may be useful in identifying highly specialized plant-pollinator relationships.

There are some other good examples of pollination systems that neatly match the expectations of the syndrome hypothesis. Surveys of Bornean gingers (Zingiberaceae and Costaceae; Sakai et al. 1999) and several neotropical *Costus* (Costaceae; Kay and Schemske 2003) species showed repeated associations of bird and insect pollination with particular patterns of floral trait combinations, although in some cases floral phenotype did not “match” the observed pollinator (e.g. Sakai et al. 1999; see Ollerton et al. 2003). Over the past decade Campbell and colleagues (Campbell 1991, 1996, Campbell et al. 1996, 1997, Mitchell and Waser 1992, Mitchell 1993, Meléndez-Ackerman and Campbell 1998) have worked out the mechanisms by which hummingbirds exert selection on the red tubular flowers and nectar production of *Ipomopsis aggregata* (Polemoniaceae). It is unlikely however that most plant species fit the syndrome hypothesis so nicely (Knuth 1906, Ollerton 1998, Ollerton and Watts 2000).

It is possible that the pollination syndrome hypothesis may explain major pollinators of certain plant families and genera, or animal taxa, such as hummingbirds and hawkmoths, but still possess little explanatory power in a broader community context (Ollerton 1998). In a community level survey, Hingston and McQuillan (2000) found that many Tasmanian plants lacked specialized floral morphology and that the visitation profiles to many species did not match syndrome predictions, but rather were correlated with the pollinator assemblage associated with the particular site or habitat. Momose et al.'s (1998) attempt to match floral characteristics in a lowland tropical forest with

pollination syndrome predictions likewise yielded limited support. Color was not an important variable in distinguishing syndromes, but floral reward and shape were. In a Japanese maritime grassland Nakano and Washitani (2003) found evidence for “bumblebee” specialization, which was associated with ‘flag’ and ‘gullet’ shapes of flowers and violet color, but not for other modes of pollination.

Ollerton and Watts (2000) conducted a multivariate analysis of the traits (e.g. color, scent, shape) commonly used to classify plants into pollination syndromes, and found that the categories themselves are not as distinct as early workers had supposed. Instead of the 11 classical syndromes their analysis identified four floral phenotype clusters (bees + butterfly + bird, moth + hawkmoth, carrion fly + beetle + wasp + fly, non-flying mammal + bat), suggesting that pollination syndromes themselves need re-examination. Had syndromes occupied discrete places in phenotypic space this would strengthen the idea that the proposed syndromes are distinct, and that floral trait combinations could be used to predict what the pollinator is (Waser et al. 1996). For example Waser (1982) and Waser and Price (1983) found that *Delphinium nelsonii* (Ranunculaceae), which possesses a typical ‘bee’ flower, is also visited and pollinated to a significant extent by hummingbirds. Barthell and Knops (1997) showed that ‘hawkmoth’ flowers were successfully pollinated by carpenter bees as well. In some cases floral morphology may be the result of net selection from a taxonomically diverse group of pollinators (Waser 1998, Herrera 1989, Gómez and Zamora 1999, Fox 1988). What this implies is that biologists should not *a priori* ascribe mode of pollination or

agent of selection based on floral traits alone (Faegri and van der Pijl 1966, Barthell and Knops 1997, Ollerton 1998, Fishbein and Venable 1996, Waser et al. 1996).

Although there is ample evidence for pollinator-mediated selection on floral traits, it is not clear to what extent the syndrome traits are the result of such selection, nor is it clear how well the syndromes predict common pollinators. If the pollination syndrome hypothesis is to be of use it should have both “predictive,” as well as “explanatory” properties. We explain the “fit” between hummingbird visitation to a plant with red tubular flowers as the product of an evolutionary history. But can we use the syndromes to actually predict what animals will visit and pollinate a flower? Pollinator identity should be highly correlated with the distribution of floral traits associated with the different syndromes, if they represent adaptations to the current pool of pollinators (Faegri and van der Pijl 1966, Ollerton 1998, Hingston and McQuillan 2000, Ollerton and Watts 2000). However, since many plant species are pollinated by a diverse group of taxa, the resulting floral morphology might be a compromise of the selective pressures from the various groups.

In this case, the degree to which a plant resembles various pollination syndromes might be a good indicator of the degree to which it is adapted to those taxa, and should be reflected in their frequency of interaction. It is also possible that the floral traits we see are adaptations to episodes of past selection, followed by a period of stasis due to variation in the pollinator assemblage (Ollerton 1996, Waser 1998, Herrera 1996, Gould and Eldredge 1993, Gould and Vrba 1982).

To assess the predictive utility of the pollination syndromes we require a quantitative assessment of a representative group of plants, as opposed to conspicuous archetypes. Surveying entire communities thus is a logical way to test the predictive value of the syndromes. It has the advantage of controlling for the available pollinator pool, which makes it possible to analyze trait-pollinator associations. In this chapter I describe the extent to which flowers from two montane meadow environments match idealized “classic” pollination syndromes derived and compiled from “textbook” descriptions (e.g. Faegri and van der Pijl 1966, Proctor et al 1996; J. Ollerton and R. Alarcón, unpublished data), and then compare the syndrome predictions to observed visitation patterns. The goal is to determine the usefulness of pollination syndromes in montane meadow communities. I addressed the following questions: 1) How closely do real plants within a well-defined community resemble idealized pollination syndromes, based on their floral characteristics? 2) Does syndrome similarity accurately predict the most frequent pollinator? 3) Does the position of a plant relative to idealized pollination syndromes in multivariate space indicate the relative frequency of visitation by alternative pollinator taxa? 4) What floral traits, if any, are correlated with the relative frequency of visitation by the different pollinator taxa?

Materials and Methods

Study Sites

This study was conducted in two montane meadow systems in different mountain ranges: the Rocky Mountains of central Colorado and the San Bernardino Mountains in

southern California. The Colorado system was a large and continuous high elevation sub-alpine meadow bordered by coniferous forest and talus slopes. The California meadows were located in smaller openings within yellow pine forests. In both systems plant-pollinator interactions were recorded in multiple years, but for Colorado I only present results for the first year.

During the summer of 2000, interactions were recorded in Virginia Basin (38° 58.6' N, 106° 58' W) near the Rocky Mountain Biological Laboratory in Gothic, CO. I established three study sites, spaced approximately 100m apart, along an elevational gradient through the basin: Low site (3385m), Middle site (3445m), and High site (3475m). In each site I set up three parallel 50m × 1m wide belt transects spaced 10m apart. I sampled flower visitation at all three sites twice a week for a period of 5 weeks (June 30-August 3). Hereafter I will refer to the Colorado meadow system as Virginia Basin.

In 2001 I established four sites, within 2 km of each other, within the Big Bear Ranger District of San Bernardino Mountains along Forest Service Road 2N10 at Metcalf Meadow (2,243m) Roadside (2,292m) YMCA Junction (2,316) and Camp Bluff Lake (2,316m; 34° 13.2' N, 116° 57.5' W). Due to a high number of endemic sensitive and endangered plant species in the San Bernardino Mountains I was unable to establish transects that ran directly through the meadows; instead I set up 3-5 50m × 1m belt transects along existing paths to minimize any trampling impact. At each site transects were surveyed for floral visitors twice a week from June 21-August 1. In 2002 I abandoned Metcalf Meadow because of a high level of human use and instead established

more transects at Camp Bluff Lake (The Wildlands Conservancy), dividing the site into two: Bluff Woods and Bluff Meadow. At each site plant-pollinator interactions were sampled once to twice a week from May 29-July 31. In 2003 I concentrated sampling efforts at both sites at Camp Bluff Lake and surveyed plant-pollinator interactions twice a week from June 16-August 6. Hereafter I will refer to the California study system as Bluff Mesa.

Flower-pollinator surveys and Floral Traits

Surveys were carried out from 09:00h-17:00h under favorable weather conditions. In Bluff Mesa I attempted to survey for crepuscular and nocturnal pollinators, but the cool temperatures limited pollinator activity and was discontinued after summer 2001. I sampled flower visitors by slowly walking (20-40 min/transect) transects and collecting all insects that came into contact with floral reproductive structures; hummingbird and hawkmoth visits were simply recorded. Large and easily identifiable insects, such as butterflies and bumblebees were released, while most insects were pinned for subsequent identification. I placed visitors into operational taxonomic units (OTU's), identified them to the finest level of resolution, and categorized OTU's into one of 7 "classic" pollinator groups: birds, moths/hawkmoths, bees, flies, beetles, wasps and butterflies. I excluded the bat and small mammal syndromes because both were absent from these meadow communities. In addition, I combined moth and hawkmoth pollinators into a single group because of their behavioral and morphological similarity, and I placed all dipterans in the fly syndrome because "carrion fly" flowers were absent from these communities.

I scored plants, found on or adjacent to transects in Bluff Mesa, for the presence (1) or absence (0) of floral traits used to define pollination syndromes (e.g. Faegri and Pijl 1966). I used the methods of Ollerton and Watts (2000), except that I did not score plants for the dominant nectar sugar (sucrose, glucose) because of the difficulty in extracting nectar from many plant species, and I reduced the number of floral traits used to score plants to 40 traits by excluding redundant traits that could be coded by a single variable. For example, I treated the time when flowers are available to pollinators, day or night, as a single variable in which I coded day as “1”, and night as “0”, as opposed to using a different variable for each. N. M. Waser followed the same protocol to score plants at Virginia Basin (Appendix 1).

Statistical Analysis

Ollerton and Watts (2000) generated a single composite of floral trait combinations, for each of the 11 classical pollination syndromes. However there are multiple trait combinations that potentially fit each syndrome. For example, flowers may or may not possess nectar guides yet still match the “bee” syndrome. J. Ollerton and R. Alarcón (unpublished; Appendix 2) generated 686-idealized pollination syndrome trait combinations as described in the literature (e.g. Faegri and Pijl 1966) and I ordinated them using PC-ORD’s (4.0) non-metric multidimensional scaling (NMDS), with each of the 41 floral traits weighed equally. NMDS ordines objects based on rank distances, such that similar objects are close to each other and dissimilar ones are far apart, while minimizing the number of dimensions that are required to preserve the distance relationships between the objects (Legendre and Legendre 1998). Each idealized

syndrome then consists of multiple alternative trait combinations, and multiple points represent this in the ordination space. The idealized syndromes were used to construct the multidimensional phenotypic space in which plant species could be assigned locations based on their floral trait combinations.

Once the idealized syndrome space was established, I then calculated the coordinates for the plant species scored in Virginia Basin and Bluff Mesa by implementing the NMDS Scores prediction algorithm in PC-ORD (4.0). The algorithm utilizes input (i.e. raw data) and output (i.e. coordinates) from a NMDS ordination analysis to calibrate the multivariate space, and then calculates the position for new objects without altering the original space. To increase the sample size for the Bluff Mesa community, I combined the visitation data for all three summers. For each community, I performed a cluster analysis (Group Average Link Method with Sorensen Distances) on the plants' NMDS coordinates, along with the 686 idealized trait combinations, to determine if plants species phenotypically resemble and group with a single pollination syndrome.

To test the idea that pollination syndromes accurately predict the most frequent pollinator, I compared the expected pollinator based on the cluster analysis to the most frequent visitor identified for plant species I had observed ≥ 5 plant-pollinator interactions. For both Bluff Mesa and Virginia Basin, I calculated the frequency with which the expected pollinator matched the most frequently observed pollinator for plant species and evaluated the predictive value of pollination syndrome through a chi-square goodness of fit test.

I also performed a discriminant function analysis (DFA) implemented through Proc Discrim in SAS (8.0), to classify flowers into syndromes and compare the most frequently observed pollinator to syndrome expectations. I used the 686 idealized trait combinations as the calibration dataset with equal prior probabilities, and then I applied the classification functions to the Bluff Mesa and Virginia Basin plant assemblages to test the predictive value of the syndrome classifications for those species for which I had recorded ≥ 5 plant-pollinator interactions.

Since many plant species are pollinated by a multiple animal taxa, the resulting floral morphology might be a compromise between the selective pressures from the various groups instead of the single most frequent pollinator. The proximity of a plant's position to idealized syndromes in multivariate space might be a good indicator of the degree to which its flowers are adapted to each pollinator taxon, and thus should be reflected in the relative frequency of interaction. For each plant species for which I had observed ≥ 5 plant-pollinator interactions I created a position vector in multidimensional space that I then correlated with the relative frequency of pollinator visits. To generate the position vectors I calculated the Euclidean distance between each plant species' position in the multidimensional phenotypic space, and the centroid of each idealized pollination syndrome. I standardized each vector by subtracting the distance to each centroid from the mean syndrome distance to all the centroids for that plant species. Syndromes closer to a species than the mean distance will have positive values whereas syndromes further than the mean distance will have negative values. I then used a Spearman rank correlation to compare the position vector to a visitation vector,

composed of the relative frequency of visits from each pollinator taxon. As an alternative approach for predicting the relative frequency of pollinator visits to plants, I compared the visitation vector for each plant species to the DFA posterior probabilities of syndrome membership from Bluff Mesa and Virginia Basin communities using Spearman Rank correlations. This is essentially a random model that specifies that the relative frequency of pollinator visits should be correlated with the frequency distribution of syndromes in each community. For example, if most of the plant species in a community possess “bee” flowers, then presumably bees should also be very abundant floral visitors.

To identify which of the floral characteristics are correlated with the visitation patterns of the various pollinator taxa (bees, beetles, birds, butterflies, flies, moths and wasps), I used NMDS to ordinate the Bluff Mesa plant assemblage based on pollinator visitation patterns, and then correlated the ordination axis with the floral traits. Unlike other ordination techniques, NMDS dimensions are arbitrary; the amount of variation accounted for by each axis does not decrease with increased dimensionality, thus the ordination can be rotated to maximize interpretation (Legendre and Legendre 1998). To simplify the presentation and interpretation of the axes, I rotated the space to maximize the correlation of the first axis with visitation by birds.

Bees as a group visited the greatest number of plant species at Bluff Mesa; association between their visitation pattern and floral characteristics might not be easily detected by the ordination. To further explore the visitation pattern of bees I used a regression tree analysis implemented in S-Plus (6.0), with floral traits as predictor variables, and the frequency of bee visits as the response variable. Regression trees use

combinations of predictor variables to partition data into groups, whereby each predictor based split attempts to minimize the sum of squares with each groups, and thereby maximally explain the variation in the response variable (De'ath and Fabricus 2000). To identify the optimal number of predictor variables needed I performed a 10-fold cross validation. With this approach the data are first partitioned into 10 equal groups, then leaving one group out a regression tree is calculated with the remaining data; this is repeated 10 times with each group being omitted once from the calculation. From the multiple runs a consensus tree is calculated and the statistical significance of this tree is established by a Monte Carlo randomization with 1000 permutations.

Results

The NMDS ordination of the 686 idealized trait combinations identified 3 axes that accounted for 88.1% of the total variation (Figure 2.1). Correlations between the idealized floral traits and the NMDS axes are summarized in Table 2.1. The relative spacing between idealized syndromes in the multivariate space resembles that of Ollerton and Watt (2000). However, points corresponding to moth and hawkmoth syndromes were intermixed, suggesting that these do not significantly differ in their floral trait combinations, so I combined these points into a single group, hawkmoth/moth, for subsequent comparisons.

Real plants from different communities can be plotted in the syndrome space without altering the original multivariate space. The distribution of plants from Bluff Mesa in the ideal syndrome space shows that most plants do not have positions that fall

within the clusters of points that represent idealized syndromes, but rather lie adjacent to or between multiple syndromes (Figure 2.2). However, it is still possible to assign plant species to a syndrome based on its position in multivariate space relative to idealized syndromes. Hierarchical cluster analysis of the Bluff Mesa plant assemblage, together with the 686 idealized trait combinations, suggests that 97% of the 67 plants species have coordinates that are similar to an idealized pollination syndrome (Table 2.2). There were two plant species however that were left unclassified; one species possessed intermediate characteristics to the fly, beetle, wasp, and carrion syndromes, while the second species did not resemble any of the idealized syndromes (Table 2.2). Figure 2.3 shows the distribution of plants from Virginia Basin within the idealized phenotypic space. Cluster analysis of these plants with the ideal trait combinations suggests that 84% of the 55 plant species resemble an idealized pollination syndrome (Table 2.3). Most of the plants that did not resemble a single pollination syndrome were intermediate between the bee and butterfly syndromes.

Even though I could ascribe most of the plant species to an idealized syndrome based on similarity in multivariate space, the predicted pollinator matched the most frequently observed pollinator in only 18% of the 44 plant species from Bluff Mesa with ≥ 5 -recorded plant-pollinator interactions (Table 2.2). Chi-square tests suggest that the most frequently observed pollinators differed significantly from the pollination syndrome classifications for Bluff Mesa ($\chi^2 = 22.36$, d. f. = 7, $p = 0.002$). Syndrome classifications based on the discriminant function analysis also failed to predict the most frequently observed pollinator for the majority of plant species from Bluff Mesa. Of the 44 plant

species, only 8 were correctly classified (Table 2.2). Error rates for syndrome classification was extreme high for all plants relative to the most frequently observed pollinator. Plants with bees as the most frequently observed pollinators were misclassified in 83.33% of the cases, 75% of the plant species primarily visited by butterflies were misclassified, 66.67% of the species visited by wasps were misclassified, while all the plants with beetles, birds, or moths as the most frequently observed pollinator were misclassified.

At Virginia Basin, syndrome resemblance in multivariate space pollinator accurately predicted the most frequent pollinator for only 1 out of 21 plant species. Chi-square tests confirmed the lack of fit between observed and predicted mode of pollination for this community ($\chi^2 = 36.28$, d. f. = 4, $p < 0.0017$). The discriminant function analysis performed slightly better by predicting the most frequent pollinator for 4 out of 21 plant species (Table 2.3). However error rates for syndrome classification again were extremely high, with species primarily visited by bees misclassified in all cases, plant species primarily visited by birds misclassified in 50% of the cases, and species with flies as the most frequent pollinators being misclassified into different syndromes in 85.71% of the species.

The use of position vectors in multivariate space to predict the relative frequency of visits from different pollinator taxa also performed rather poorly. Spearman rank correlations suggest that position vectors were correlated with visitation profiles for only 13.6 % of 44 plant species from Bluff Mesa (Table 2.4). In Virginia Basin only 1 out of 21 plant species had their position vectors positively correlated with the relative visitation

pattern (Table 2.5). However, none of the correlations between the relative frequencies of pollinator visits to the DFA posterior probabilities of plant membership into each syndrome were statistically significant for either the Bluff Mesa (Table 2.4) or Virginia Basin (Table 2.5) plant assemblages.

The NMDS ordination of the Bluff Mesa plant assemblage based on pollinator visitation patterns explained 76.9% of the variation along two axes (Figure 2.4). The graph is a joint plot in which I display the coordinates for the plants, pollinators, and vectors for the floral characteristics, where the angle and length of the vectors show the direction and strength of the relationship. For presentation purposes, I only show the vectors for floral characteristics with $r \geq 0.30$ (Table 2.6). Axis 1 is positively correlated with long, tube shaped flower, stiff anthers, and abundant nectar, while negatively correlated with small to medium flower size, white and green coloration. Bird and butterfly visits are also positively correlated with axis 1, whereas bee, fly and wasp visits are negatively correlated with axis 1 (Table 2.6). Although moth, fly and beetle visitation are positively correlated with axis 2, and bee and butterfly visits are negatively correlated with the axis, most of the floral trait correlations are very small, with the time flowers are open being the only trait moderately correlated with the axis (Table 2.6).

To better understand the floral trait that best predict bee visitation I performed a regression tree analysis. The regression tree that best described bee visitation at Bluff Mesa was marginally statistically significant ($p = 0.091$); it partitioned plant species into 3 groups using 2 predictor variables (Figure 2.6). The analysis suggests that bees frequently visited flowers with short corollas and zygomorphic symmetry (mean

frequency of visits = 0.65, $n = 8$), whereas non-zygomorphic flowers received moderate levels of visitation (mean frequency of visits = 0.37, $n = 29$). Flowers with long corollas received few visits from bees (mean frequency of visits = 0.07, $n = 7$).

Discussion

Pollination syndromes have been used to explain the evolution of floral phenotype and angiosperm diversification. It has been argued that the distribution of floral characters in a community may serve to partition pollinators such that each plant specializes on a different taxon and occupies a distinct “pollination niche” (Parrish and Bazzaz 1979, Wilson and Thomson 1996). However, the predictive utility of the pollination syndrome concept has yet to be rigorously tested for a representative group of plant species. This is partly due to the difficulty in devising a means for establishing a template of idealized floral phenotypes to compare real plants against. Ollerton and Watts’ (2000) multivariate analysis of 11 classical syndromes pioneered the way for establishing a hypothetical floral phenotype space. However, the pollination syndrome trait combinations used in that study were actually composites of trait combinations that fit the syndrome concept. In recognizing that multiple trait combinations correspond to each idealized syndrome Ollerton and Alarcón (unpublished) derived 686 combinations from the literature as the basis for establishing a multivariate phenotypic space to compare floristic assemblages. Ordination of these idealized trait combinations supports Ollerton and Watts’ (2000) earlier conclusion that some of the idealized syndromes are rather close to each other in multivariate space, suggests they resemble one another and

overlap in the floral characteristics they possess. This is especially true in the case of the moth and hawkmoth syndromes, for which the multiple trait combinations were intermingled, suggesting that these syndromes are not significantly differentiated and thus should be lumped into one group for the purpose of establishing an idealized space for classifying plants into a single pollination syndrome.

In calculation the positions for plants from the Bluff Mesa and Virginia Basin assemblages, I found that none of the plant species had coordinates in the phenotypic space that fell within the scatter of multiple points that represent the idealized syndromes, but rather were adjacent to them. This suggests that real flowers do not perfectly “match” the descriptions of idealized pollination syndromes, which is not unexpected. However, cluster analyses showed that for the most part, flowers do resemble pollination syndromes, and are similar enough such that they can be grouped into syndrome based on their floral characteristics. In a few cases, flowers had positions that were intermediate between pollination syndromes that also cluster together, suggesting that those plant species might possess “mixed” floral trait combinations. Thus, although real plants do not possess the exact trait combinations that idealized syndromes do, they still resemble pollination syndromes to a remarkable degree.

However, syndrome similarity did not match the most frequently observed pollinator in most cases. In Bluff Mesa predictions were met for only 8 plants species, regardless of the classification method used. Predictions based on the hierarchical clustering of plants with the idealized trait combinations matched the most frequent pollinator for 5 “bee” flowers, 2 “butterfly” flowers, and one “moth/hawkmoth” flower,

whereas the discriminant functions matched 3 “bee” flowers, 3 “fly” flowers 1 “wasp” flower and 1 “butterfly” flower. One striking problem with both classification techniques is that they failed to accurately classify both plant species primarily visited by hummingbirds, even though they possess some of the typical floral characteristics associated with the bird syndrome. For example the two species, *Castilleja miniata* and *Penstemon labrosus* (Scrophulariaceae), were placed into the butterfly syndrome by the cluster approach, while DFA placed them into the moth and wasp syndrome, respectively. This highlights the danger of trying to predict the mode of pollination based on floral traits alone, especially when the syndromes themselves are not phenotypically distinct. It may also be the case that the floral traits associated with idealized syndromes are not all important to the pollinators. In those cases where the observed matched the expected pollinator, the plants might have possessed some of the more important traits from a pollinator’s perspective. Regardless, attempting to predict the most frequent pollinator based on idealized pollination syndromes does not work for most of the plants in Bluff Mesa.

In Virginia Basin the observed most frequent pollinator matched the expected for only one out of 20 plant species using the clustering technique, while the DFA accurately predicted the most frequent pollinator for 4 plant species. In four out of the 5 correct classifications the observed most frequent pollinators were flies. In this meadow system insect community composition might especially reduce the fit between observed and expected pollinators. At higher elevations the abundance of most insects groups tends to decline, except for flies. Thus flies are relatively more abundant and are the most

frequent floral visitors to many plant species (Kearns 1992). So in high elevation communities, such as Virginia Basin, the lack of insect diversity greatly reduces the predictive utility of pollination syndrome because most pollinator taxa are likely to be rare or absent from the community.

The alternative approach, of using the location of a plant relative to the idealized syndromes in multivariate space as an estimate of the relative visits from different pollinators, also fared poorly. Very few position vectors were positively correlated with visitation patterns. Ideally, the proximity of a plant's coordinates in multivariate space to a syndrome should reflect its phenotypic similarity, and this should translate into relative visitation rates. For example, if a flower is more similar to the moth syndrome than to the bird syndrome, then it should receive more visits from moths relative to birds. However, given that pollination syndromes overlap in floral characteristics it is difficult to determine which traits pertain to each syndrome. In addition, pollinators might not respond equally to all of the syndrome floral characteristics. It is possible that even though a flower resembles one pollination syndrome more than another, the traits shared with the second syndrome might be functionally more important and lead to more visits by pollinators that correspond to the second syndrome. However, the use of DFA posterior classification probabilities for syndrome membership failed to predict the relative frequency of pollinator visits for any of the plants in either community, suggesting that pollinators do not visit randomly, or if they do that the relative abundance of pollinators is not coupled with the frequency distribution of syndromes within these communities.

The lack of fit between observed and predicted pollinators does not mean that floral traits are unimportant in structuring plant-pollinator interactions. Rather than depending on the descriptions of pollination syndromes to predict *a priori* what floral traits pollinators “prefer,” biologists should identify these characteristics for each community separately to take into account the particular composition of plants and pollinators. Correlations between floral characteristics and visitation patterns for the Bluff Mesa assemblage suggest that traits that influence the “morphological fit” between flowers and pollinators tend to be more important in influencing the observed visitation patterns as compared to signaling traits such as color or scent type. This may be because animals are opportunistic and will collect nectar and pollen rewards from flower they are not mechanically restricted from doing so. The visitation patterns also suggest that the different pollinators do not necessarily visit flowers with different characteristics. For example, hummingbirds and butterflies seem to preferentially visit flowers with long corollas and abundant nectar volumes. These pollinator-trait associations are not at odds with the bird and butterfly pollination syndromes but rather emphasize the difficulty of determining the mode of pollination based on floral characteristics. Fly visitation seemed to be associated with traits typical of the fly syndrome, such as open, small to medium flowers, and white coloration, but these characteristics do not prevent other types of pollinators from visiting, except if the rewards are too small to be profitable (Lamborn and Ollerton 2000). Flowers with these characteristics may appear to be “fly” flowers just because these are the only flowers that flies have access to.

As with the bird and butterfly visitation patterns, traits that influence the “morphological fit” between flowers and pollinators and access to rewards appear to be important for structuring bee visitation patterns. Although bees visited a wide diversity of floral forms, regression tree analysis suggests that flowers with short corolla tubes and zygomorphic symmetry are associated with relatively more bee visitation. Perhaps this is because other pollinators are excluded while bees are not, or that other pollinators that respond positively to these characteristics are rare in the community.

Functional floral and pollinator phenotypes, which affect access to floral rewards, are probably more important in determining which species interact with each other, as opposed to visual and olfactory signals (Muchhala 2003). Although most plants from these communities can be classified into a pollination syndrome, only in a few cases does the expected pollinator match the most frequently observed visitor. This is because the idealized syndromes themselves are not phenotypically different from each other, and many of the traits used to place plants into syndromes are not equally important. The moth syndrome might be an exception, but the lack of “moth syndrome” flowers at Bluff Mesa makes it difficult to make any generalizations. It is likely however, that pollination syndromes might only be useful in predicting the relative frequency of visits between pollinator taxa that differ significantly in their morphology or foraging behavior. Rather than attempt to refine the pollination syndromes in order to predict plant-pollinator associations, it might be more fruitful to move beyond these archetypical descriptions and focus on the functional phenotype of plants and pollinators that limit access to rewards. Such characteristics are likely to be under strong selection pressure to exclude “floral

reward thieves” and increase the relative effectiveness of true pollinators. Novel approaches, such as the morphometric analysis of an entire plant-pollinator community, might be able to uncover useful features that will aid in the description and prediction of plant-pollinator interactions.

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Table 2.1

Pearson correlations between floral traits and axes from non-metric multidimensional scaling ordination of idealized pollination syndromes. Large correlations ($r \geq 0.5$) are in boldface.

Feature	Floral Trait	Axis 1	Axis 2	Axis 3
		r	r	r
Shape	Trap Morphology	-0.148	0.381	-0.336
	Open Morphology	-0.340	0.396	-0.238
	Bell Morphology	-0.030	0.018	-0.138
	Brush Morphology	-0.025	-0.131	0.333
	Gullet Morphology	0.159	-0.154	0.312
	Flag Morphology	0.210	-0.332	-0.053
	Tube Morphology	0.224	-0.074	0.512
Symmetry	Zygomorphic	0.706	-0.215	-0.200
Size	Medium/Small	0.757	-0.240	-0.144
	Mechanically Strong	-0.238	-0.539	-0.194
Flower	Pendant	0.096	0.004	0.184
Orientation	Upright	0.041	-0.114	-0.170
	Horizontal	-0.047	0.057	0.052
Anthers	Stiff Anthers	-0.433	-0.500	-0.005
	Exposed Anthers	-0.577	-0.174	-0.437
Tube Morphology	Narrow Opening	0.366	-0.692	0.441
	Wide Opening	0.500	-0.081	-0.185
	Short Flower	0.598	-0.514	-0.249
	Long Flower	0.129	-0.301	0.646
Time of Opening	Day	0.638	-0.386	-0.548
Odor Strength	Strong Odor	-0.595	0.886	0.120
	No Scent	-0.031	-0.714	-0.036
Scent Type	Sweet Scent	-0.127	0.184	0.687
	Fruity Scent	-0.182	0.289	-0.225
	Fresh Scent	0.765	-0.320	-0.108
	Musky Scent	-0.371	0.088	0.123
	Sour Scent	-0.269	0.310	-0.150
	Decaying Scent	-0.066	0.527	-0.249
Color Brightness	Vivid	0.600	-0.887	-0.094
Color	Brown	-0.402	0.448	-0.369
	White	-0.368	0.438	-0.010
	Red	0.064	-0.291	0.297
	Green	-0.207	-0.210	-0.005
	Yellow	0.329	0.054	0.008
	Blue	0.243	-0.424	-0.042
	Purple	0.333	0.056	-0.079

Table 2.1 continued

Feature	Floral Trait	Axis 1	Axis 2	Axis 3
		r	r	r
Nectar	Nectar Guides	0.646	-0.675	-0.377
	Present	-0.014	-0.455	0.097
Nectar Volume	Abundant	-0.527	-0.453	0.335
	Moderate	0.573	-0.038	0.032

Table 2.2

Most frequently observed and expected pollinators for Bluff Mesa plant assemblage. Expected syndrome was calculated in two ways: 1) discriminant function analysis (DFA) and 2) cluster analysis of non-metric multidimensional scaling (NMDS) coordinates of plants and idealized syndromes (See Figure 2.2). I identified the most frequently pollinator for plant species for which I had observed ≥ 5 plant-pollinator interactions.

Species	Family	Most Frequent		
		Pollinator	DFA	NMDS & Cluster
<i>Heracleum lanatum</i>	Apiaceae	bee	fly	beetle
<i>Perideridia parishii</i>	Apiaceae	bee	fly	unclassified
<i>Sphenosciadium capitellatum</i>	Apiaceae	bee	mammal	wasp
<i>Apocynum androsaemifolium</i>	Apocynaceae	-	-	wasp
<i>Achillea millefolium</i>	Asteraceae	fly	moth	moth
<i>Arnica chamissonis</i>	Asteraceae	butterfly	butterfly	butterfly
<i>Aster occidentalis</i>	Asteraceae	bee	fly	butterfly
<i>Chamomilla suaveolens</i>	Asteraceae	-	-	unclassified
<i>Cirsium tioganum</i>	Asteraceae	wasp	moth	butterfly
<i>Erigeron divergens</i>	Asteraceae	fly	bird	butterfly
<i>Eriophyllum lanatum</i>	Asteraceae	beetle	moth	butterfly
<i>Madia elegans</i>	Asteraceae	bee	butterfly	butterfly
<i>Madia glomerata</i>	Asteraceae	-	-	butterfly
<i>Taraxacum officinale</i>	Asteraceae	bee	butterfly	butterfly
<i>Tragopogon dubius</i>	Asteraceae	-	-	butterfly
<i>Arabis holboellii</i>	Brassicaceae	-	-	butterfly
<i>Erysimum capitatum</i>	Brassicaceae	beetle	bird	butterfly
<i>Lepidium virginicum</i>	Brassicaceae	wasp	beetle	bee
<i>Symphoricarpos rotundifolius</i>	Caprifoliaceae	fly	butterfly	wasp
<i>Silene verecunda</i>	Caryophyllaceae	-	-	moth
<i>Spergularia rubra</i>	Caryophyllaceae	fly	fly	bee
<i>Stellaria crispa</i>	Caryophyllaceae	-	-	wasp
<i>Hypericum anagalloides</i>	Clusiaceae	-	-	bee
<i>Arctostaphylos sp.</i>	Ericaceae	-	-	butterfly
<i>Lotus nevadensis</i>	Fabaceae	bee	bird	bee
<i>Lotus oblongifolius</i>	Fabaceae	-	-	bee
<i>Lotus pershianus</i>	Fabaceae	-	-	butterfly
<i>Lupinus andersonii</i>	Fabaceae	bee	bee	bee
<i>Lupinus latifolius</i>	Fabaceae	fly	bat	butterfly
<i>Lupinus lepidus</i>	Fabaceae	bee	bee	butterfly
<i>Lupinus polyphyllus</i>	Fabaceae	bee	bat	butterfly
<i>Trifolium longipes</i>	Fabaceae	bee	bee	butterfly
<i>Geranium richardsonii</i>	Geraniaceae	bee	fly	bee
<i>Ribes nevadensis</i>	Grossulariaceae	bee	butterfly	butterfly

Table 2.2 continued

Species	Family	Most Frequent		
		Pollinator	DFA	NMDS & Cluster
<i>Phacelia imbricata</i>	Hydrophyllaceae	bee	moth	butterfly
<i>Iris hartwegii</i>	Iridaceae	-	-	butterfly
<i>Monardella linoides</i>	Lamiaceae	wasp	wasp	bee
<i>Stachys albens</i>	Lamiaceae	bee	fly	bee
<i>Lilium parryi</i>	Liliaceae	moth	mammal	moth
<i>Sidalcea pedata</i>	Malvaceae	butterfly	fly	bee
<i>Veratrum californicum</i>	Melanthraceae	fly	fly	bee
<i>Epilobium angustifolium</i>	Onagraceae	bee	fly	fly
<i>Epilobium ciliatum</i>	Onagraceae	-	-	butterfly
<i>Epilobium glaberrimum</i>	Onagraceae	-	-	butterfly
<i>Gayophytum diffusum</i>	Onagraceae	fly	fly	bee
<i>Epipactis gigantea</i>	Orchidaceae	-	-	bee
<i>Plantanthera leucostachys</i>	Orchidaceae	butterfly	wasp	butterfly
<i>Collomia linearis</i>	Polemoniaceae	fly	moth	butterfly
<i>Polygonum bistoroides</i>	Polygoniaceae	-	-	beetle
<i>Calyptridium umbellatum</i>	Portulacaceae	fly	bat	bee
<i>Aquilegia formosa</i>	Ranunculaceae	butterfly	bird	moth
<i>Ranunculus alismaefolius</i>	Ranunculaceae	beetle	bird	butterfly
<i>Thalictrum fendleri</i>	Ranunculaceae	-	-	bat
<i>Horkelia rydbergii</i>	Rosaceae	bee	fly	bat
<i>Potentilla anserina</i>	Rosaceae	-	-	bee
<i>Potentilla glandulosa</i>	Rosaceae	fly	beetle	bat
<i>Potentilla gracilis</i>	Rosaceae	bee	fly	bee
<i>Prunus virginiana</i>	Rosaceae	beetle	fly	fly
<i>Rosa californica</i>	Rosaceae	beetle	fly	fly
<i>Kellogia galioides</i>	Rubiaceae	-	-	butterfly
<i>Castilleja miniata</i>	Scrophulariaceae	bird	moth	butterfly
<i>Mimulus guttatus</i>	Scrophulariaceae	-	-	butterfly
<i>Mimulus moschatus</i>	Scrophulariaceae	-	-	butterfly
<i>Pedicularis semibarbarata</i>	Scrophulariaceae	-	-	bee
<i>Penstemon caesius</i>	Scrophulariaceae	moth	wasp	butterfly
<i>Penstemon grinnellii</i>	Scrophulariaceae	-	-	butterfly
<i>Penstemon labrosus</i>	Scrophulariaceae	bird	wasp	butterfly

Table 2.3

Most frequently observed and expected pollinators for Virginia Basin plant assemblage. Expected syndrome was calculated in two ways: 1) discriminant function analysis (DFA) and 2) cluster analysis of non-metric multidimensional scaling (NMDS) coordinates of plants and idealized syndromes (See Figure 2.3). I identified the most frequently pollinator for plant species for which I had observed ≥ 5 plant-pollinator interactions.

Species	Family	Most Frequent		
		Pollinator	DFA	NMDS & Cluster
<i>Ligusticum porteri</i>	Apiaceae	fly	fly	fly
<i>Pseudocymopterus montanus</i>	Apiaceae	fly	bird	butterfly
<i>Achillia lanulosa</i>	Asteraceae	fly	bird	butterfly
<i>Agoseris aurantiaca</i>	Asteraceae	-	-	butterfly
<i>Agoseris glauca</i>	Asteraceae	fly	moth	butterfly
<i>Antennaria rosea</i>	Asteraceae	-	-	moth
<i>Arnica cordifolia</i>	Asteraceae	-	-	bee, butterfly
<i>Arnica parryi</i>	Asteraceae	bee	moth	butterfly
<i>Arnica rydbergii</i>	Asteraceae	-	-	butterfly
<i>Cirsium scopulorum</i>	Asteraceae	-	-	butterfly
<i>Erigeron elatior</i>	Asteraceae	fly	fly	butterfly
<i>Erigeron peregrinus</i>	Asteraceae	-	-	bee, butterfly
<i>Erigeron speciosus</i>	Asteraceae	fly	moth	butterfly
<i>Helenium hoopesii</i>	Asteraceae	fly	bird	butterfly
<i>Helianthella quinquenervis</i>	Asteraceae	fly	bird	butterfly
<i>Heterotheca villosa</i>	Asteraceae	bee	bird	butterfly
<i>Senecio bigelovii</i>	Asteraceae	-	-	butterfly
<i>Senecio crassulus</i>	Asteraceae	fly	moth	bee, butterfly
<i>Solidago spathulata</i>	Asteraceae	-	-	butterfly
<i>Mertensia ciliata</i>	Boraginaceae	-	-	butterfly
<i>Arabis drummondii</i>	Brassicaceae	-	-	butterfly
<i>Descurainia pinnata</i>	Brassicaceae	-	-	wasp
<i>Lonicera involucrata</i>	Caprifoliaceae	-	-	butterfly
<i>Arenana congesta</i>	Caryophyllaceae	-	-	bee, butterfly
<i>Sedum integrifolium</i>	Crassulaceae	-	-	beetle
<i>Sedum stenopetalum</i>	Crassulaceae	-	-	bee, butterfly
<i>Astragalus alpinus</i>	Fabaceae	-	-	butterfly
<i>Lathyrus leucanthus</i>	Fabaceae	-	-	butterfly
<i>Vicia americana</i>	Fabaceae	bee	bird	butterfly
<i>Gentiana heterosepala</i>	Gentianaceae	-	-	butterfly
<i>Gentianella amarella</i>	Gentianaceae	bee	moth	wasp
<i>Gentianella parryi</i>	Gentianaceae	-	-	butterfly
<i>Gentianopsis detonsa</i>	Gentianaceae	-	-	butterfly
<i>Geranium richardsonii</i>	Geraniaceae	fly	fly	butterfly

Table 2.3 continued

Species	Family	Most Frequent		
		Pollinator	DFA	NMDS & Cluster
<i>Hydrophyllum fendleri</i>	Hydrophyllaceae	-	-	wasp
<i>Zygadenus elegans</i>	Liliaceae	-	-	bee, butterfly
<i>Linum lewisii</i>	Linaceae	fly	bird	butterfly
<i>Epilobium angustifolium</i>	Onagraceae	-	-	butterfly
<i>Polemonium pulcherrimum</i>	Polimoniaceae	-	-	beetle
<i>Polygonum bistortoides</i>	Polygoniaceae	-	-	bee, butterfly
<i>Androsace septentrionalis</i>	Primulaceae	-	-	bee, butterfly
<i>Aquilegia caerulea</i>	Ranunculaceae	-	-	butterfly
<i>Delphinium barbeyi</i>	Ranunculaceae	bird	bee	butterfly
<i>Fragaria virginiana</i>	Rosaceae	-	-	butterfly
<i>Potentilla fruticosa</i>	Rosaceae	fly	bird	butterfly
<i>Potentilla sp.</i>	Rosaceae	fly	bird	butterfly
<i>Castilleja miniata</i>	Scrophulariaceae	bird	bird	butterfly
<i>Castilleja occidentalis</i>	Scrophulariaceae	bee	moth	butterfly
<i>Castilleja rhexifolia</i>	Scrophulariaceae	-	-	bee, butterfly
<i>Pedicularis bracteosa</i>	Scrophulariaceae	-	-	butterfly
<i>Pedicularis groenlandica</i>	Scrophulariaceae	-	-	butterfly
<i>Pedicularis racemosa</i>	Scrophulariaceae	-	-	butterfly
<i>Penstemon whippleanus</i>	Scrophulariaceae	-	-	butterfly
<i>Valeriana edulis</i>	Valerianaceae	-	-	butterfly
<i>Valeriana occidentalis</i>	Valerianaceae	fly	butterfly	butterfly

Table 2.4

Spearman Rank Correlations (Rho) for the Bluff Mesa plant assemblage comparing the relative frequency of pollinator visits to: 1) a plant's position relative to idealized syndromes in the NMDS multivariate space (See Figure 2.2), and 2) DFA posterior probabilities for syndrome membership (See Methods). Significant correlations are in boldface.

Species	Family	NMDS		DFA	
		position vector		probability vector	
		<i>Rho</i>	<i>p-value</i>	<i>Rho</i>	<i>p-value</i>
<i>Heracleum lanatum</i>	Apiaceae	0.356	0.217	-0.125	0.748
<i>Perideridia parishii</i>	Apiaceae	0.36	0.214	0.066	0.866
<i>Sphenosciadium capitellatum</i>	Apiaceae	-0.09	0.424	0.004	0.991
<i>Achillea millefolium</i>	Asteraceae	-0.288	0.265	0.093	0.813
<i>Arnica chamissonis</i>	Asteraceae	0.709	0.037	0.03	0.939
<i>Aster occidentalis</i>	Asteraceae	0.414	0.178	0.066	0.866
<i>Cirsium tioganum</i>	Asteraceae	0.018	0.458	0.168	0.665
<i>Erigeron divergens</i>	Asteraceae	-0.505	0.124	0.22	0.57
<i>Eriophyllum lanatum</i>	Asteraceae	-0.473	0.142	-0.089	0.821
<i>Madia elegans</i>	Asteraceae	-0.144	0.379	0.004	0.991
<i>Taraxacum californicum</i>	Asteraceae	0.089	0.425	0.196	0.612
<i>Erysimum capitatum</i>	Brassicaceae	-0.037	0.469	-0.139	0.722
<i>Lepidium virginicum</i>	Brassicaceae	0.749	0.026	0.256	0.507
<i>Symphoricarpos rotundifolius</i>	Caprifoliaceae	0.045	0.462	0.324	0.396
<i>Spergularia rubra</i>	Caryophyllaceae	0.493	0.131	0.306	0.423
<i>Lotus nevadensis</i>	Fabaceae	0.436	0.164	0.075	0.847
<i>Lupinus andersonii</i>	Fabaceae	0.337	0.23	-0.157	0.686
<i>Lupinus latifolius</i>	Fabaceae	-0.595	0.08	0.066	0.866
<i>Lupinus lepidus</i>	Fabaceae	0.449	0.156	-0.256	0.507
<i>Lupinus polyphyllus</i>	Fabaceae	-0.432	0.166	0.004	0.991
<i>Trifolium longipes</i>	Fabaceae	0.378	0.201	-0.066	0.866
<i>Geranium richardsonii</i>	Geraniaceae	0.468	0.144	-0.128	0.743
<i>Ribes nevadensis</i>	Grossulariaceae	-0.045	0.462	-0.497	0.197
<i>Phacelia imbricata</i>	Hydrophyllaceae	-0.089	0.425	0.196	0.612
<i>Monardella linoides</i>	Lamiaceae	0.401	0.186	-0.139	0.722
<i>Stachys albens</i>	Lamiaceae	0.906	0.002	0.196	0.614
<i>Lilium parryi</i>	Liliaceae	0.27	0.279	0.132	0.735
<i>Sidalcea pedata</i>	Malvaceae	-0.433	0.166	0.03	0.939
<i>Veratrum californicum</i>	Melanthraceae	0.401	0.186	0.139	0.722
<i>Epilobium angustifolium</i>	Onagraceae	0.478	0.139	-0.126	0.747
<i>Gayophytum diffusum</i>	Onagraceae	0.593	0.08	0.046	0.946
<i>Plantanthera leucostachys</i>	Orchidaceae	0.134	0.388	-0.15	0.7
<i>Collomia linearis</i>	Polemoniaceae	-0.089	0.425	0.324	0.396
<i>Calyptridium umbellatum</i>	Portulacaceae	0.811	0.013	0.251	0.514

Table 2.4 continued

Species	Family	NMDS position vector		DFA probability vector	
		<i>Rho</i>	<i>p- value</i>	<i>Rho</i>	<i>p- value</i>
<i>Aquilegia formosa</i>	Ranunculaceae	0.757	0.024	0.312	0.414
<i>Ranunculus alismaefolius</i>	Ranunculaceae	-0.591	0.081	-0.241	0.533
<i>Horkelia rydbergii</i>	Rosaceae	-0.655	0.055	0.19	0.624
<i>Potentilla glandulosa</i>	Rosaceae	0.037	0.469	0.009	0.981
<i>Potentilla gracilis</i>	Rosaceae	0.487	0.134	0.119	0.76
<i>Prunus virginiana</i>	Rosaceae	0.437	0.142	-0.241	0.533
<i>Rosa californica</i>	Rosaceae	0.591	0.081	-0.13	0.738
<i>Castilleja miniata</i>	Scrophulariaceae	-0.018	0.485	0.128	0.743
<i>Penstemon caesius</i>	Scrophulariaceae	0.079	0.433	0.476	0.195
<i>Penstemon labrosus</i>	Scrophulariaceae	0.837	0.009	0.166	0.669

Table 2.5

Spearman Rank Correlations (Rho) for the Virginia Basin plant assemblage comparing the relative frequency of pollinator visits to: 1) a plant's position relative to idealized syndromes in the NMDS multivariate space (See Figure 2.3), and 2) DFA posterior probabilities for syndrome membership (See Methods). Significant correlations are in boldface.

Species	Family	Multivariate position vector		DFA posteriori probability vector	
		<i>Rho</i>	<i>p-value</i>	<i>Rho</i>	<i>p-value</i>
<i>Ligusticum porteri</i>	Apiaceae	0.802	0.015	-0.047	0.904
<i>Pseudocymopterus montanus</i>	Apiaceae	-0.334	0.232	0.17	0.662
<i>Achillea lanulosa</i>	Asteraceae	-0.788	0.018	-0.266	0.488
<i>Agoseris glauca</i>	Asteraceae	-0.223	0.316	0.236	0.541
<i>Arnica parryi</i>	Asteraceae	-0.267	0.281	0.189	0.626
<i>Erigeron elatior</i>	Asteraceae	0.185	0.345	0.057	0.885
<i>Erigeron speciosus</i>	Asteraceae	-0.408	0.182	0.283	0.46
<i>Helenium hoopesii</i>	Asteraceae	-0.187	0.344	0.313	0.412
<i>Helianthella quinquenervis</i>	Asteraceae	-0.168	0.359	0.036	0.926
<i>Heterotheca villosa</i>	Asteraceae	0.089	0.425	0.189	0.626
<i>Senecio crassulus</i>	Asteraceae	0.541	0.105	-0.252	0.513
<i>Vicia americana</i>	Fabaceae	0.408	0.182	0	1
<i>Gentianella amarella</i>	Gentianaceae	-0.309	0.25	0	1
<i>Geranium richardsonii</i>	Geraniaceae	-0.49	0.132	-0.047	0.904
<i>Linum lewisii</i>	Linaceae	-0.12	0.399	-0.021	0.958
<i>Potentilla fruticosa</i>	Linaceae	-0.408	0.182	0.283	0.46
<i>Potentilla sp.</i>	Linaceae	-0.234	0.307	0.062	0.875
<i>Delphinium barbeyi</i>	Ranunculaceae	0.445	0.158	0.472	0.199
<i>Castilleja miniata</i>	Scrophulariaceae	0.49	0.132	0.472	0.199
<i>Castilleja occidentalis</i>	Scrophulariaceae	-0.197	0.336	-0.031	0.937
<i>Valeriana occidentalis</i>	Valerianaceae	-0.49	0.132	-0.047	0.904

Table 2.6

Correlations between floral traits and pollinator visitation with NMDS axes from the ordination of the Bluff Mesa plant assemblage. The ordination explains for 76.9% of the variation in visitation to plants (See Figure 2.4). Moderate to large correlations ($r \geq 0.3$) are in boldface.

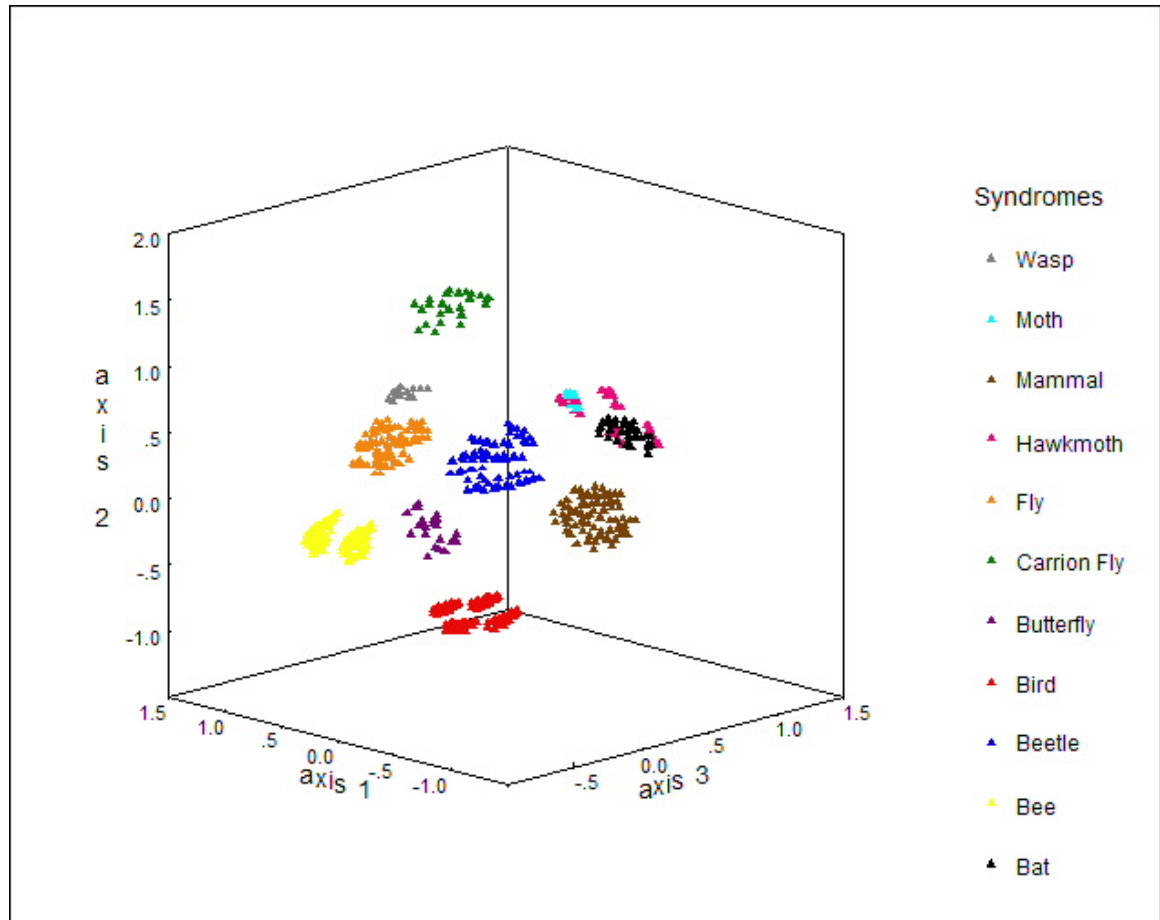
Feature	Floral Trait	Axis 1	Axis 2
		r	r
Shape	Trap Morphology	-	-
	Open Morphology	-0.244	0.171
	Bell Morphology	-0.03	0.281
	Brush Morphology	0.08	-0.104
	Gullet Morphology	-0.131	-0.141
	Flag Morphology	-0.162	-0.234
	Tube Morphology	0.421	-0.111
Symmetry	Zygomorphic	0.022	-0.229
Size	Medium/Small	-0.601	-0.002
	Mechanically Strong	-0.058	-0.083
Flower	Pendant	0.275	0.003
Orientation	Upright	-0.092	-0.077
	Horizontal	0.006	0.008
Anthers	Stiff Anthers	0.368	-0.227
	Exposed Anthers	-0.007	0.008
Tube Morphology	Narrow Opening	0.109	-0.101
	Wide Opening	0.389	-0.053
	Short Flower	-0.207	-0.087
	Long Flower	0.718	-0.069
Time of Opening	Day	-0.23	-0.336
Odor Strength	Strong Odor	0.087	0.132
	No Scent	0.308	0.091
Scent Type	Sweet Scent	0.131	-0.043
	Fruity Scent	-0.039	0.093
	Fresh Scent	-0.163	0.063
	Musky Scent	-0.038	-0.064
	Sour Scent	-0.195	0.005
	Decaying Scent	-0.066	-0.084
Color Brightness	Vivid	0.118	0.111
Color	Brown	-0.151	-0.268
	White	-0.422	0.274
	Red	0.27	-0.071
	Green	-0.311	0.253
	Yellow	0.135	-0.132
	Blue	-0.102	-0.151
	Purple	-0.14	-0.096

Table 2.6 continued

Feature	Floral Trait	Axis 1	Axis 2
		r	r
Nectar	Nectar Guides	-0.282	0.012
	Present	-	-
Nectar Volume	Abundant	0.664	0.04
	Moderate	0.108	-0.07

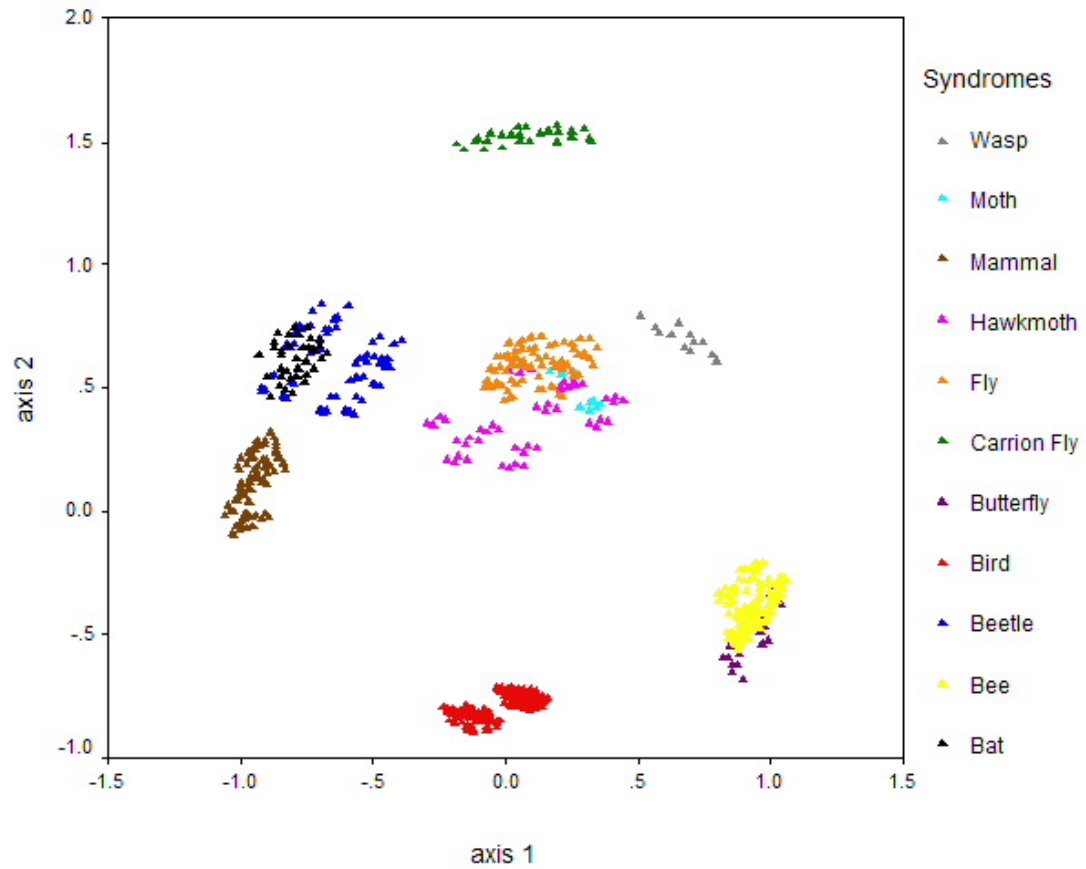
Pollinator Visits			
Butterfly	0.574	-0.518	
Beetle	0.137	0.354	
Bee	-0.484	-0.563	
Moth	0.275	0.477	
Bird	0.535	-0.013	
Fly	-0.42	0.559	
Wasp	-0.396	-0.088	

Figure 2.1a



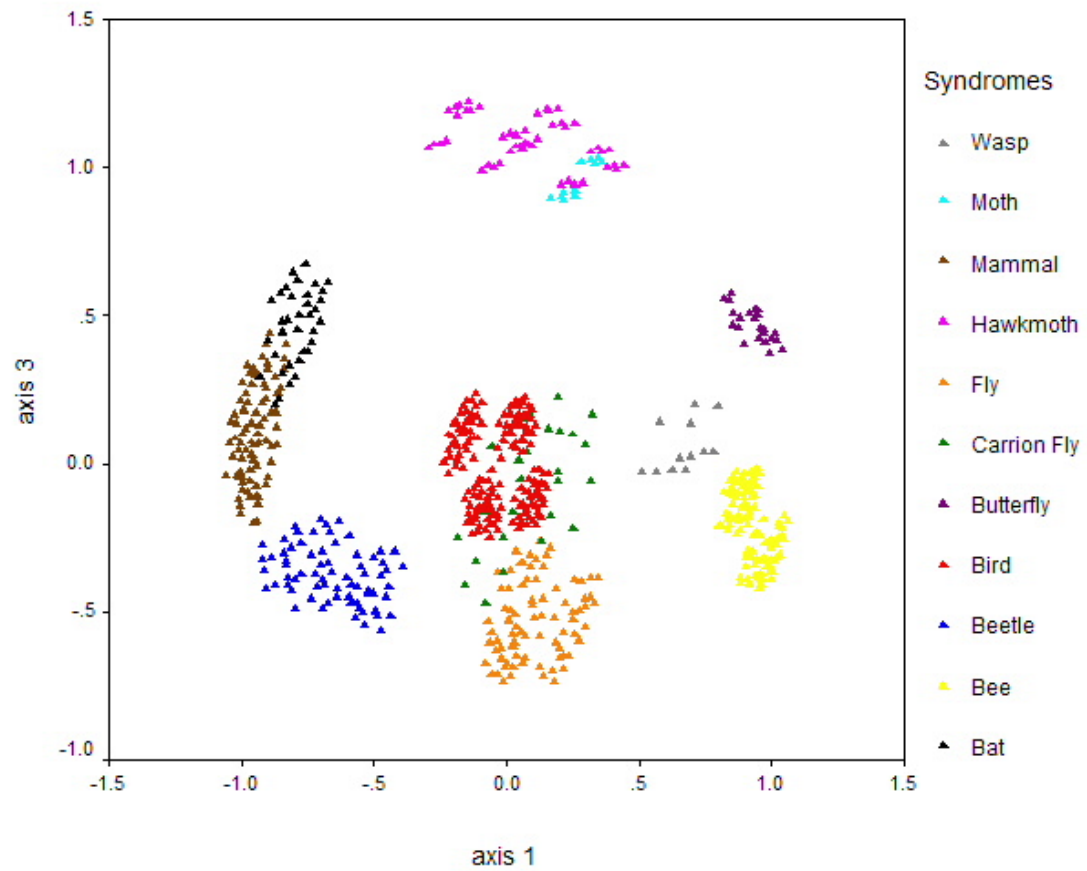
Three-dimensional ordination (Non-metric multidimensional scaling, N-MDS) of 686-idealized pollination syndrome trait combinations as described in the literature (e.g. Faegri and Pijl 1966). Each idealized syndrome consists of multiple alternative trait combinations and this is representative by multiple points. For clarity and presentation the pollination syndromes are also graphed in two dimensions for axes pairs: 1b) Axes 1 and 2, 1c) Axes 1 and 3, 1d) Axes 2 and 3. Points for the hawkmoth and moth syndromes are intermixed, suggesting that they are not significantly different from each other. For explanation of the axes see Results.

Figure 2.1b



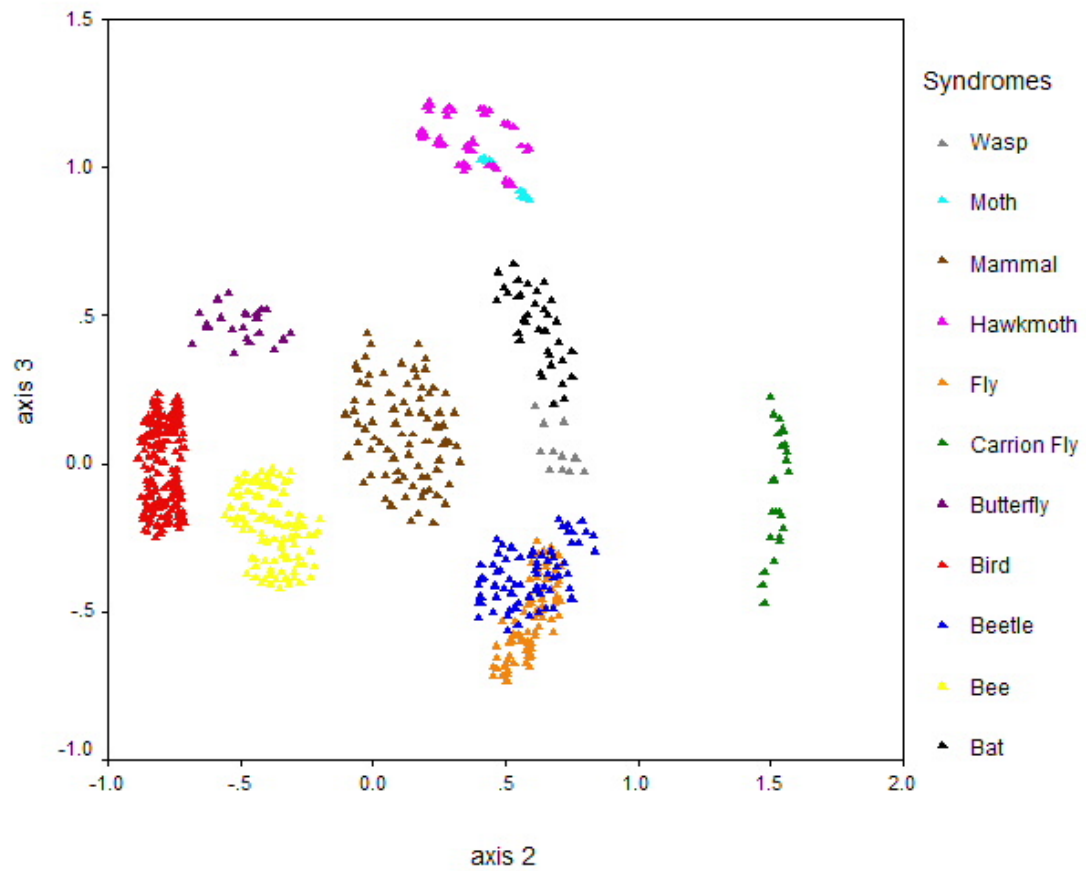
Two-dimensional graph of idealized pollination syndromes along axes 1 and 2. See Figure 1a for explanation.

Figure 2.1c



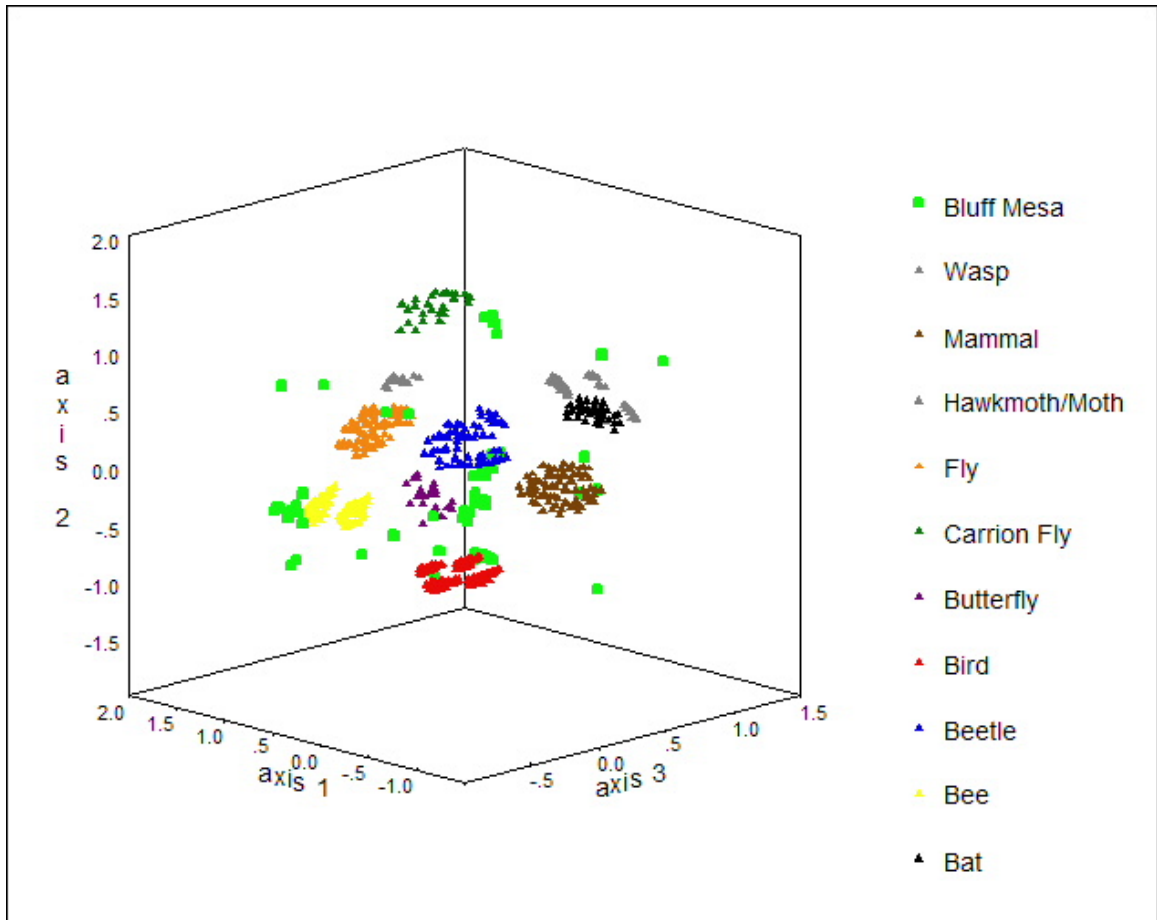
Two-dimensional graph of idealized pollination syndromes along axes 1 and 3. See Figure 1a for explanation.

Figure 2.1d



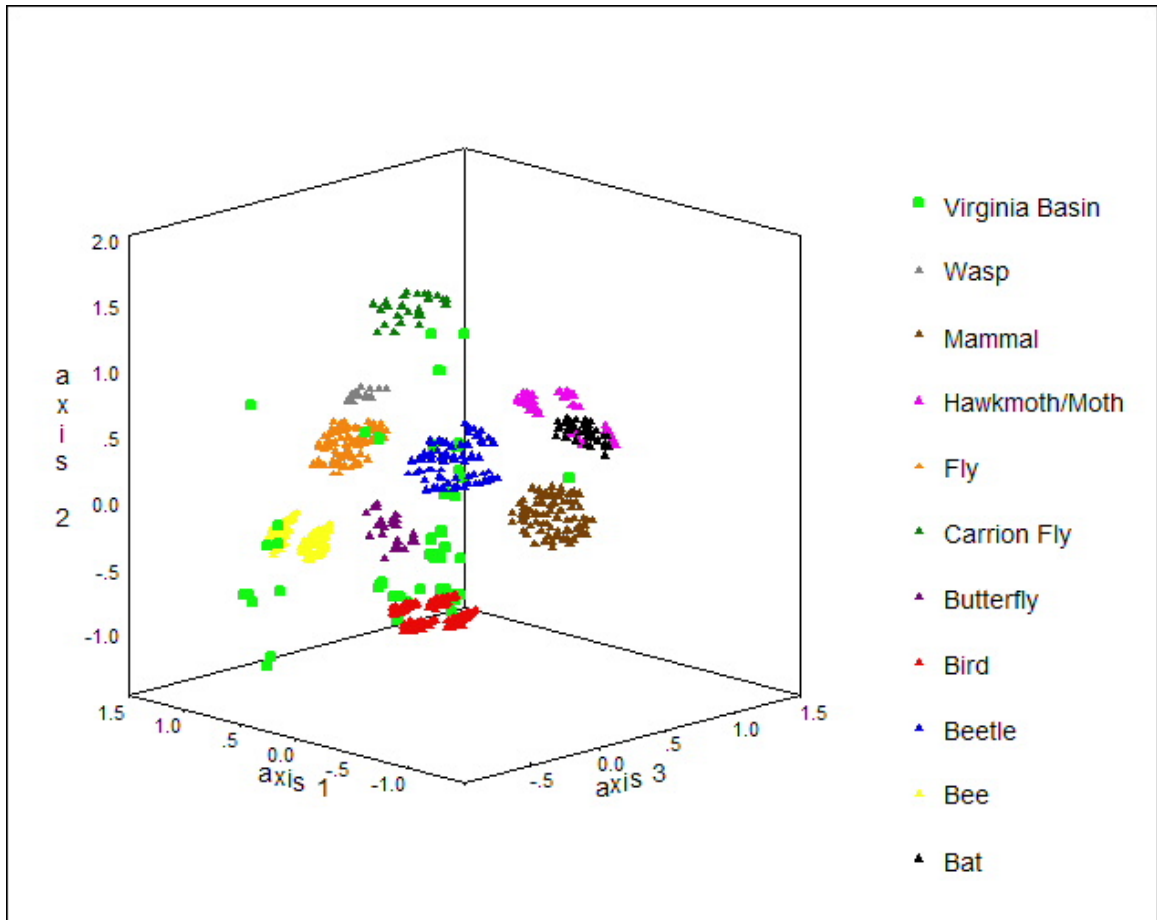
Two-dimensional graph of idealized pollination syndromes along axes 2 and 3. See Figure 1a for explanation.

Figure 2.2



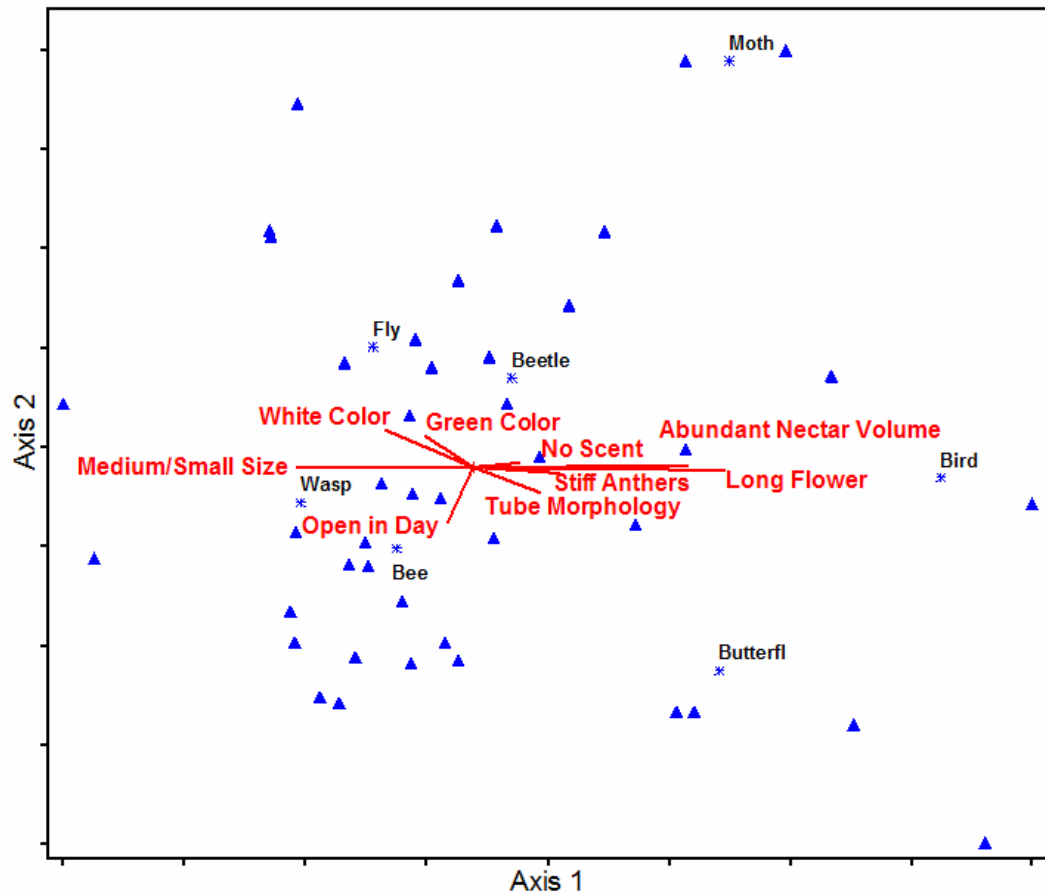
The distribution of the Bluff Mesa plant assemblage within the three-dimensional idealized phenotypic space. Plants were scored using the same floral traits used by Ollerton and Watts (2000). Ordination of idealized pollination syndromes (non-metric multidimensional scaling) was used to construct the phenotypic space (See Figure 1); then the plants' positions (green circles) were calculated in that space. Real plants do not cluster within the scatter of points that represent the idealized syndromes, but rather have positions that adjacent to or are intermediate to syndromes.

Figure 2.3



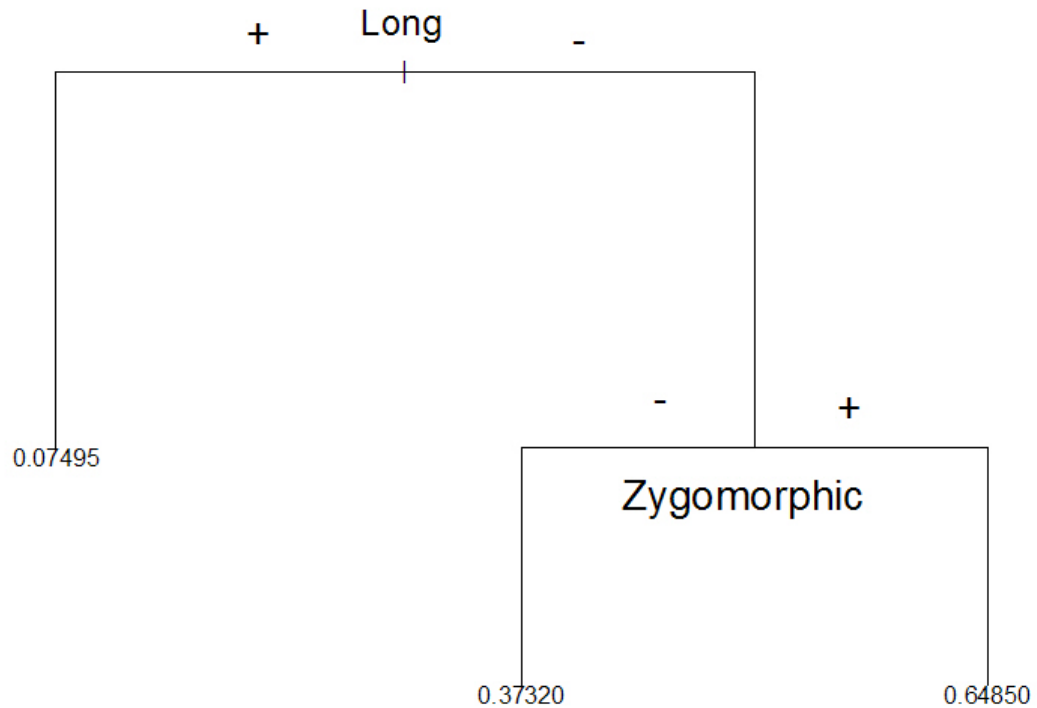
The distribution of the Virginia Basin plant assemblage within the three-dimensional idealized phenotypic space. Plants were scored using the same floral traits used by Ollerton and Watts (2000). Ordination of idealized pollination syndromes (non-metric multidimensional scaling) was used to construct the phenotypic space (See Figure 1); then the plants' positions (green circles) were calculated in that space. Real plants do not cluster within the scatter of points that represent the idealized syndromes, but rather have positions that adjacent to or are intermediate to syndromes.

Figure 2.4



Ordination (non-metric multidimensional scaling) of the Bluff Mesa plant assemblage based on the relative frequency of pollinator visits. The graph is a joint plot displaying the coordinates for pollinators (asterisk), plants (triangles) and vectors for floral trait correlations ($r > 0.3$), where the angle and length of the vectors show the direction and strength of the relationship with the axes (See Table 6). For presentation purposes, I rotated the space to maximize the correlation of axis 1 with hummingbird visitation. Axis 1 explains 49.4% and axis 2 explains 23.7% of the variation in pollinator visits to plants.

Figure 2.5



The regression tree describing the relative proportion of bee visits to plant species at Bluff Mesa using floral tube length and symmetry as predictor variables. Predictor variables partition the data into more homogeneous groups to minimize the sum of squares with each group, and explain the variation in the response variable. A relatively small proportion of the visits to flowers with long tubes (+ Long) were from bees, whereas flowers with short tubes (- Long) and radial symmetry (- Zygomorphic) received a moderate level of bee visits. However most of the visits to flowers with short-tubes and zygomorphic symmetry (- Long, + Zygomorphic) were from bees.

CHAPTER 3

COMMUNITY-WIDE PATTERNS OF POLLEN CARRIED ON INSECT BODIES, AND IMPLICATIONS FOR THE “QUALITY” COMPONENT OF POLLINATOR EFFECTIVENESS TO PLANTS

Introduction

The study of biotic pollination of plants relies heavily on observations of which animal species visit flowers. But visitation is not synonymous with pollination, it is just one component of successful pollination; the visitor must also transfer viable pollen to a receptive stigma of the same species. Flower visitors often vary in their ability to remove and transfer pollen; some visitors may actually be “robbers” or “cheaters” in the sense that they do not provide pollination services for resources they receive (Barrows 1976, Herrera 1987, Bronstein 1994, Thompson 1996, Irwin et al. 2001). It is possible that many of the plant-animal interactions described in recent community level studies might not constitute pollination, but rather have null or negative effects on plant fitness. Thus attempts to describe the properties of plant-pollinator networks based on visitation patterns alone might actually say very little about the fitness consequences of such interactions without estimates of pollinator effectiveness.

Given the magnitude and difficulty of measuring pollen deposition rates for a diverse plant and pollinator community, a suitable proxy and first approximation for pollinator “quality” might be to analyze the pollen found on the bodies of floral visitors. One of the strengths of this approach is that it is possible to analyze the pollen loads of a large sample of insects in a relatively short time, making the approach feasible for a community level study. Gaining knowledge of which visitors actually transfer pollen, and in what amounts, allows us to greatly improve an understanding of pollination of single plant species or of larger groups of species, up to the level of an entire plant community. Knowledge of which insects or other animals carry pollen also allows

comparison across major groups of putative pollinators, for example across the insect orders (bees, flies, butterflies, moths beetles, wasps) from which most pollinators are drawn. Because the pollen on the body of an individual insect or other animal represents some record of what that individual has visited in the past, this also provides insight into past foraging specialization or generalization of the individual.

Finally, when some key assumptions are met (which I will take up in the Discussion), information on pollen carried on the bodies of pollinators can be used to compare two components of the "effectiveness" of pollinators from the plant's point of view. The "Most Effective Pollinator Principle" (Stebbins 1970), posits that the most frequent *and* most effective visitor, on a per visit basis, will drive floral evolution in a given area. The frequency of an observed plant-pollinator interaction is often referred to the "quantity" component of pollination, whereas the per-visit effectiveness, or amount of conspecific pollen deposited on a stigma, is the "quality" component of pollination (Waser and Price 1983, Herrera 1987, 1989). From the plant's perspective then, the fitness consequences of a particular plant-pollinator interaction is the product of the "quantity" and "quality" components of pollination (Herrera 1987, 1989).

Stebbins' (1970) "principle" implies that the two components of pollination are positively associated with each other, because plants should evolve characteristics that increase the number of visits from high quality pollinators or to ensure more effective pollen transfer from frequent visitors. Thus, the agent of selection on floral morphology should be readily identified from a pool of potential pollinators based on the product of both components. However, the quality and quantity of pollination might not tightly

linked, even though both components determine the intensity of plant-pollinator interactions (Waser and Price 1983, Herrera 1989, 1996, Mayfield et al. 2001). In some cases the more frequent visitors are the less effective pollinators on a per visit basis, and vice versa (Beattie 1971, Motten et al. 1981, Olsen 1997, Mayfield et al 2001).

Although several studies have documented that floral visitors can vary in the quantity and quality aspects of pollination (e.g. Montalvo and Ackerman 1986, Herrera 1987, 1989, 1990, Waser and Price 1990, Jennersten and Morse 1991, Fishbein and Venable 1996, Olsen 1997, Potts et al. 2001), to my knowledge no one has examined this relationship at the community level. Surveying entire communities is a logical way to assess the utility of the most effective pollinator principle. Furthermore, if visitation patterns are positively associated with estimates of pollinator effectiveness, then the analysis of plant-animal interaction networks might serve to link community scale patterns with angiosperm evolution.

In this chapter I addressed the following questions: 1) Do different groups of insect pollinators vary in their per visit “quality,” as measured by the composition of the pollen load they carry on their bodies? 2) What is the relationship between the number of plants species visited by insect pollinators, or their degree of generalization, with the abundance and diversity of foreign pollen, as well as the abundance and relative proportion of conspecific pollen carried on their bodies? 3) At the community level, is “quantity,” or frequency of observed interactions between plant and pollinator species, positively associated with the “quality,” or abundance and relative proportion of conspecific pollen carried by the pollinators?

Materials and Methods

Study Sites

In 2001 I established four field sites, within 2 km of each other, within the Big Bear Ranger District of San Bernardino Mountains along Forest Service Road 2N10 at Metcalf Meadow (2,243m), Roadside (2,292m), YMCA Junction (2,316), and Camp Bluff Lake (2,316m; 34° 13.2' N, 116° 57.5' W). I set up 3-5 50m × 1m belt transects along existing paths to minimize any trampling impacts in meadows. At each site transects were surveyed for floral visitors twice a week from June 21-August 1. In 2002 I replaced the Metcalf Meadow transects with new transects Camp Bluff Lake because of a high level of human use. At each site plant-pollinator interactions were sampled once to twice a week from May 29-July 31.

Flower-pollinator surveys

Surveys were carried out from 09:00h-17:00h under favorable weather conditions. I sampled flower visitors by slowly walking (20-40 min/transect) transects and collecting all insects that came into contact with floral reproductive structures; hummingbird and hawkmoth visits were simply recorded. Large and easily identifiable insects, such as butterflies, bumblebees, and honeybees were usually released, while other insects were pinned for subsequent identification. Visitors were placed into operational taxonomic units (OTU), identified to family and placed into the nominal groups commonly recognized by pollination biologists: beetles, flies, bees, wasps, moths, and butterflies.

Once insects were pinned and sorted I removed the pollen from their bodies by dabbing them with a small cube (~1 mm³) of fuchsin jelly, making sure not to remove

pollen from specialized pollen carrying structures found on most bees (Kearns and Inouye 1993), however pollen was not collected from insects that were released in the field. I then placed each fuchsin jelly cube on a glass slide, melted it and covered it with a cover slip to produce a single layer of stained pollen grains. I counted all the “conspecific” and “foreign” pollen grains on each slide by comparing the pollen morphology to a reference pollen library taken from plants at the study site. I assumed pollen grains to be “conspecific” if they morphologically matched the pollen from the plant species that the insect was captured on. I did not identify “foreign” pollen to species because pollen morphology tends to be conserved within (and sometimes across) plant families. Instead, I classified foreign pollen based on morphology and counted the number of pollen grains for each “foreign” morphotype.

Statistical Analysis

I combined the data from both 2001 and 2002; only those insects from which pollen samples were collected were included in analyses. I used ANOVA and *post hoc* Bonferroni tests, which adjust p-values to control for experimentwise error, to compare the composition of insect pollen loads between beetles, flies, bees, wasps, and butterflies; I did not consider moths because too few specimens were collected. Specifically, I compared the mean total number of pollen grains found on insect bodies, the mean number of conspecific pollen grains, mean number of foreign pollen grains, mean number of foreign pollen morphotypes and mean proportion of conspecific pollen carried by each group of insects. Each species was treated as an individual sample, thus for each variable I calculated the mean value for each species and used it as the species’ score. To meet

the assumptions of homogeneity of variance and normality I log-transformed the values for the total abundance of pollen grains, conspecific pollen, and foreign pollen.

To determine if the degree of generalization is associated with pollen load quality at the community level, I first calculated the degree of generalization for each pollinator species by summing the total number of different plant species that each insect species visited during the summers of 2001 and 2002. I then compared this to the mean value for each of the following pollen variables: log number of conspecific pollen grains, relative proportion of conspecific pollen in pollen load, log number foreign pollen grains, and number of different foreign morphotypes found in pollen loads.

To test for the overall correlation between the “quantity” and “quality” of insect pollination for this community I compared the plant by insect frequency of visitation matrix, where each cell entry is the observed frequency of floral visits by a pollinator to each plant species, to a matrix of the same size, in which each cell contains the mean number of conspecific pollen grains carried by the individuals of a particular pollinator species that visited the plant species. I also compared the frequency of visitation matrix to a second matrix where the cell entries are the mean relative proportion of conspecific pollen carried by individuals. Only those pollinator species that carried pollen, and plant species for which at least one visitor carried conspecific pollen, were considered for the analysis. For both comparisons, I used PC-ORD (4.0) to perform a Mantel test to evaluate the strength of the association between the datasets. The Mantel statistic varies from -1 to 1 , and is analogous to a Pearson pairwise correlation between corresponding cells of the two matrices; significance of the test statistic is determined through a Monte

Carlo randomization whereby the cell values are shuffled and then the Mantel statistic is calculated for each of 1000 randomized matrices and compared to the observed value. However, the Mantel test can only be used to compare pairs of “ $n \times n$ ” distance matrices with the same dimensions, so I collapsed and summarized the plant by insect visitation and pollen matrices into symmetric plant-by-plant distance matrices using Sorensen’s distance measure.

Results

During the course of the 2001 and 2002 field seasons I recorded 2,119 plant-insect visits between 56 plant species and 211 insect species. Insects carried a mean of 182.2 (s. e. = 48.3) conspecific pollen grains, and 120.1 (s. e. = 29.6) foreign pollen grains with a mean of 1.77 (s. e. = 0.02) different foreign pollen morpho-types.

Bee species carried significantly more pollen on their bodies than any other group (Table 3.1, Figure 3.1), with an average of 658.9 pollen grains (s. e. = 181.4, $n = 65$). Analysis of the log-transformed number of conspecific pollen grains also suggests that the different groups varied in the amount of conspecific pollen they carried (Table 3.2, Figure 3.2). Bee species carried significantly more conspecific pollen grains than either flies or butterflies (mean = 457.7, s. e. = 155.6, $n = 62$; mean = 51.4, s. e. = 12.6, $n = 61$; mean = 26.4, s. e. = 18.2, $n = 7$, for bees, flies and butterflies respectively). The conspecific pollen loads of beetles and wasps, however, were not statistically different from the other insect pollinator groups.

Bee species also carried a significantly greater proportion of conspecific pollen than flies, whereas the frequencies of conspecific pollen carried by wasps, beetles, and

butterflies were not statistically different from any insect groups. (Table 3.3, Figure 3.3). Most insects carried pollen loads with ~50% conspecific pollen, whereas flies had pollen loads containing ~35% of conspecific pollen.

Bees carried significantly more foreign pollen than any other insect group (mean = 229.4, s. e. = 76.4, n = 63; Table 4, Figure 4). Bees also carried more distinct pollen morphotypes (mean = 2.48, s. e. = 0.15, n = 66; Table 5, Figure 5), than beetles, flies and butterflies. Wasps carried 1.89 (s. e. = 0.26, n = 27) foreign pollen morpho-types, which was significantly greater than beetles.

The number of plant species insects visited, or degree of generalization, was not correlated with any aspect of insect pollen load quality (Table 6). Instead the log abundance of conspecific pollen was positively correlated with the log abundance of foreign pollen ($r = 0.603$, $p < 0.001$), number of foreign pollen morpho-types ($r = 0.603$, $p < 0.001$), and the proportion of conspecific pollen in insects' pollen load ($r = 0.467$, $p < 0.001$). The log abundance of foreign pollen was also positively correlated with the number of foreign pollen morpho-types ($r = 0.745$, $p < 0.001$).

I compared the floral visitation patterns and pollen load data for 170 pollinator and 49 plant species within the community. The frequency visits to plants by pollinator species is positively associated with both the mean number of conspecific pollen grains (Mantel statistic " r " = 0.502, $p = 0.001$) and the mean proportion of conspecific pollen carried by the various insect species (Mantel statistic " r " = 0.675, $p = 0.001$).

Discussion

To date this is the first community level study to show that flower visitors do in fact usually carry pollen from the plant species that they visit and that estimates of pollinator “quantity” are positively associated with pollinator “quality.” Pollinator species that I observed to interact frequently with particular plant species tended to carry proportionately more pollen from that species, thus it is likely that visitation rates also reflect pollinator effectiveness or how different pollinator species could influence plant fitness. This also suggests that the visitation network I described in Chapter 1 is a suitable indicator of the true pollination web at Bluff Mesa. These results also add legitimacy to the recent studies that utilize visitation patterns to answer questions pertaining to the specialization/generalization of pollination systems (e.g. Waser et al. 1996, Memmott 1999, Dicks et al. 2002, Olesen and Jordano 2002, Bascompte et al. 2003, Dupont et al 2003, Jordano et al. 2003, Nakano and Washitani 2003, Vázquez and Aizen 2003, 2004).

This approach does make some critical assumptions. The key assumption is that the amount of pollen carried on the bodies of insects represents an equilibrium between input of new pollen picked up as the insect forages, and output of pollen deposited on flowers, and that the portion of the equilibrium amount which is turned over in each visit to a flower through input and output is similar across insect species. To my knowledge no previous studies have examined this assumption, although other workers have also used amount of pollen on insect bodies as a proxy for amount picked up and deposited per floral visit (e.g., Beattie 1971). However, insofar as insect bodies have similar

morphological properties (segmentation into three body parts, a chitinous exoskeleton), the turnover of pollen carried on them may be similar across insect species. I have proceeded here on the basis that turnover properties are indeed similar across species, so that equilibrium pollen load on bodies can serve as a proxy for turnover and an index of the "quality" component of pollinator effectiveness.

My analysis of insect pollen loads showed that most individuals carry mixed pollen. This suggests that individual pollinators do not specialize on a single plant species while foraging, but rather visit multiple plant species to obtain pollen and nectar resources. However, I found no relationship between the total number of plant species pollinator species were observed to visit, and the pollen load carried by insects. Although insect pollen load data do suggest that most individuals had recently foraged on more than one plant species at the time of capture, they underestimate the degree of resource generalization for the entire local population of a given insect species, possibly because of pollen load turnover and sequential flowering. With each flower visit an insect will pick up and deposit pollen, but as the floral composition changes, so will the identity of the pollen it carries. Thus the pollen carried on an insect's body only estimates the individual's short-term degree of specialization or generalization. However, the pollen carried by insects does have implications for individual fitness and gene flow among plant species. Although most individuals carried approximately twice as much conspecific pollen as foreign pollen, the presence of mixed pollen loads on animal bodies could have negative fitness consequences for both male and female plant functions if insects deposit foreign pollen on receptive stigmas, which can reduce seed set and wastes

pollen (Waser 1978a, 1978b, Campbell 1985, Campbell and Motten 1985). Such interspecific pollen transfer between sympatric plant populations could also result in introgression or the formation of hybrids. Given that most plants are visited by several pollinator species and that most individuals carry pollen from multiple plant species, it is unlikely pollination systems alone could serve as isolating mechanisms for incipient plant species.

The analysis of pollen loads also suggests that different insect groups varied in the abundance and composition of the pollen they carried on their bodies. Bees tended to carry more pollen overall, with larger conspecific pollen loads than most of the other insect groups. This might be expected given that bees often actively forage for pollen. However in terms of the proportion of conspecific pollen on insect bodies, bees were not superior to most of the other insect pollinator taxa, except for perhaps flies. Even though bees carried more conspecific pollen than other types of pollinators they also carried a greater number and diversity of foreign pollen grains. Although the pollen received from a bee visit might not be of higher purity than what could be deposited by a butterfly or wasp, bees could deposit more conspecific pollen on a single visit and thus produce a larger fitness gain. Coupled with their higher visitation rates, bees are the most important group of insect pollinators in this meadow system.

Although the “quantity” and “quality” components of pollination might be positively associated with each other at the community level, this does not mean that floral evolution necessarily follows the same observed patterns of pollination. Effective pollination and pollinator-mediated selection may be decoupled in many systems (Aigner

2001). Differences in pollen deposition, or removal, between pollinator species are not sufficient to cause floral evolution unless these differences are associated with variation in floral morphology. For instance, if a pollinator species is equally effective at pollinating flowers of a particular plant species across the entire range of floral variation, then it is unlikely that the pollinator will drive floral evolution. However, if a second pollinator is more effective at pollinating flowers across a narrow range of phenotypic variation, the plant population can evolve specialized floral adaptations to the second pollinator species as long as the net fitness gain of adapting to that species is greater than the fitness loss from becoming less adapted to the first pollinator species (Aigner 2001). However, further work is needed to help us understand how flowers evolve in generalized pollination systems.

Based on this community level comparison of insect pollen loads and floral visitation patterns it appears that both multiplicative components of pollination, “quantity” and “quality,” are positively associated with each other. It still remains to be determined if in a community context insects transfer pollen to receptive stigmas in proportion to what they carry on their bodies. If so, then floral visitation patterns would reflect overall patterns of pollination. Indeed, visitation would be a good proxy for pollination so long as pollen moved per visit is anything other than strongly negatively correlated with visitation. However, further work is needed to determine if and how frequently the most effective pollinator is also the agent of selection before the observed community level visitation patterns can be used to explain patterns of floral evolution. As suggested in Chapter 2, most of the floral traits associated with pollination syndromes

are not associated with visitation patterns, except for traits that influence access to floral rewards, thus further efforts then should be taken to measure pollen deposition and removal rates in relation to floral phenotypic variation for traits that might limit access to nectar or pollen, for as many representative species in a community as possible.

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Table 3.1

ANOVA and *post hoc* Bonferroni multiple comparisons of the log-transformed mean number of total pollen grains carried by the different insect pollinator taxa (see Figure 3.1). Significant group differences are in boldface.

Source	df	Sum of Squares	Mean Square	F	P
Between groups	4	49.329	12.332	16.889	< 0.001
Within groups	188	137.28	0.73		
Total	192	186.609			

Bonferroni Comparisons		Mean Difference		
(I)	(J)	(I-J)	S. E.	P
Bee	Beetle	0.766	0.228	0.009
	Butterfly	1.585	0.304	< 0.001
	Fly	1.077	0.145	< 0.001
	Wasp	0.713	0.198	0.004
Beetle	Butterfly	0.819	0.349	0.200
	Fly	0.311	0.224	1.000
	Wasp	-0.053	0.262	1.000
Butterfly	Fly	-0.508	0.301	0.939
	Wasp	-0.872	0.330	0.090
Fly	Wasp	-0.364	0.194	0.627

Table 3.2

ANOVA and *post hoc* Bonferroni multiple comparisons of the log transformed mean number of conspecific pollen grains carried by the various insect pollinator taxa (see Figure 3.2). Significant group differences are in boldface.

Source	df	Sum of Squares	Mean Square	F	P
Between groups	4	33.916	8.479	11.345	< 0.001
Within groups	165	123.316	0.747		
Total	169	157.232			

Bonferroni Comparisons		Mean Difference		
(I)	(J)	(I-J)	S. E.	P
Bee	Beetle	0.548	0.237	0.217
	Butterfly	1.335	0.345	0.002
	Fly	0.969	0.156	0.000
	Wasp	0.429	0.211	0.437
Beetle	Butterfly	0.787	0.388	0.443
	Fly	0.421	0.237	0.779
	Wasp	-0.119	0.277	1.000
Butterfly	Fly	-0.366	0.345	1.000
	Wasp	-0.906	0.373	0.162
Fly	Wasp	-0.540	0.212	0.116

Table 3.3

ANOVA and *post hoc* Bonferroni multiple comparisons of the mean proportion of conspecific pollen carried by insect pollinator taxa (see Figure 3.3). Significant group differences are in boldface.

Source	df	Sum of Squares	Mean Square	F	P
Between groups	4	1.314	0.329	3.349	0.011
Within groups	204	20.014	0.098		
Total	208	21.328			

Bonferroni Comparisons		Mean Difference		
(I)	(J)	(I-J)	S. E.	P
Bee	Beetle	0.055	0.078	1.000
	Butterfly	0.105	0.111	1.000
	Fly	0.172	0.051	0.009
	Wasp	0.006	0.072	1.000
Beetle	Butterfly	0.050	0.125	1.000
	Fly	0.117	0.076	1.000
	Wasp	-0.049	0.091	1.000
Butterfly	Fly	0.067	0.110	1.000
	Wasp	-0.099	0.121	1.000
Fly	Wasp	-0.166	0.069	0.174

Table 3.4

ANOVA and *post hoc* Bonferroni multiple comparisons of the log transformed mean number of foreign pollen grains carried by the different insect pollinator taxa (see Figure 3.4). Significant group differences are in boldface.

Source	df	Sum of Squares	Mean Square	F	P
Between groups	4	31.085	7.771	11.099	< 0.001
Within groups	177	123.934	0.700		
Total	181	155.019			

Bonferroni Comparisons		Mean Difference		
(I)	(J)	(I-J)	S. E.	P
Bee	Beetle	0.911	0.229	0.001
	Butterfly	1.300	0.333	0.001
	Fly	0.835	0.145	0.000
	Wasp	0.642	0.198	0.014
Beetle	Butterfly	0.388	0.376	1.000
	Fly	-0.077	0.226	1.000
	Wasp	-0.270	0.263	1.000
Butterfly	Fly	-0.465	0.332	1.000
	Wasp	-0.658	0.358	0.675
Fly	Wasp	-0.193	0.195	1.000

* Significant at the $p < 0.05$ level

Table 3.5

ANOVA and *post hoc* Bonferroni multiple comparisons of the mean number of distinct foreign pollen morphotypes carried by the various insect pollinator taxa (see Figure 3.5). Significant group differences are in boldface.

Source	df	Sum of Squares	Mean Square	F	P
Between groups	4	60.723	15.181	10.886	< 0.001
Within groups	204	284.479	1.395		
Total	208	345.202			

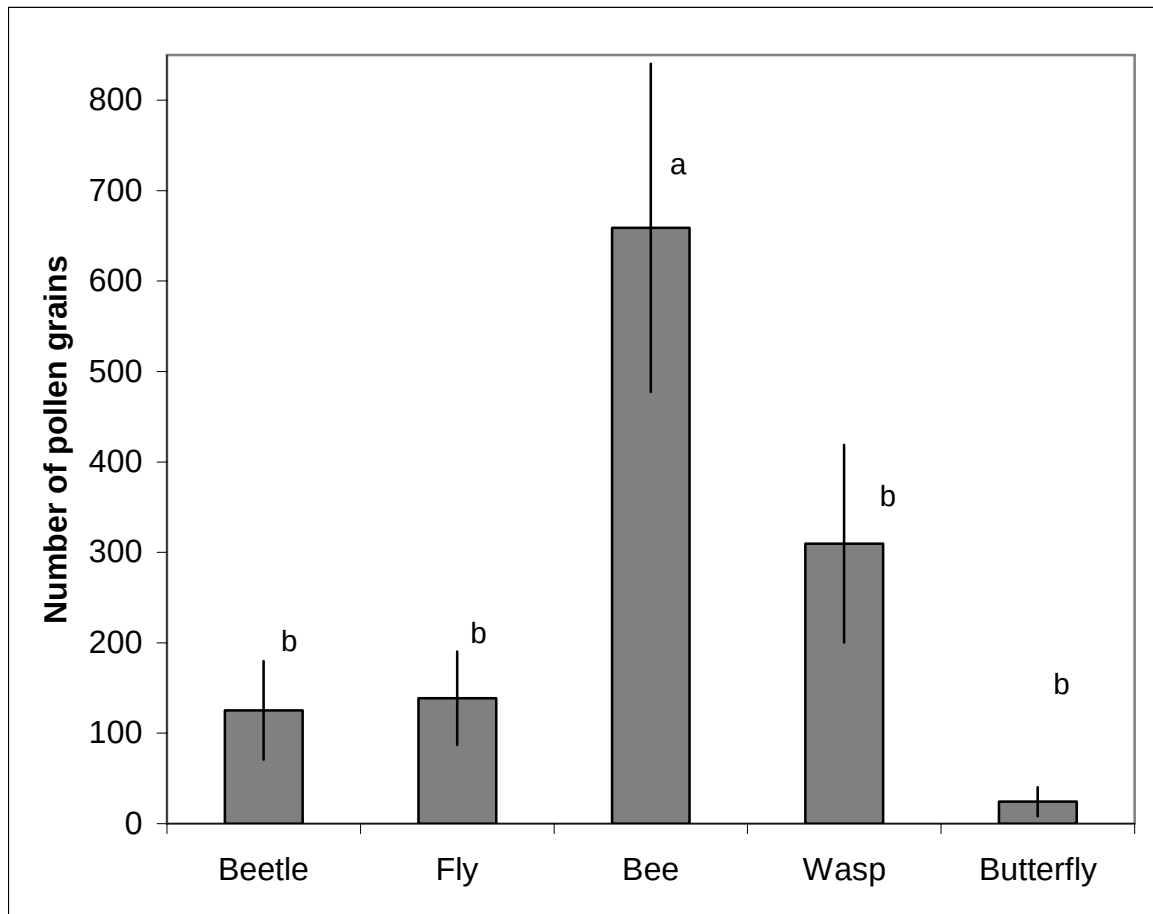
Bonferroni Comparisons		Mean Difference		
(I)	(J)	(I-J)	S. E.	P
Bee	Beetle	1.466	0.296	< 0.001
	Butterfly	1.497	0.420	0.004
	Fly	1.042	0.193	< 0.001
	Wasp	0.590	0.270	0.299
Beetle	Butterfly	0.031	0.471	1.000
	Fly	-0.423	0.287	1.000
	Wasp	-0.876	0.344	0.115
Butterfly	Fly	-0.455	0.414	1.000
	Wasp	-0.907	0.455	0.473
Fly	Wasp	-0.452	0.261	0.840

Table 3.6

Pearson pairwise correlations between the degree of generalization and pollen load size and composition for insect pollinator species at Bluff Mesa. Significant correlations are in boldface (2-tailed, $p < 0.05$).

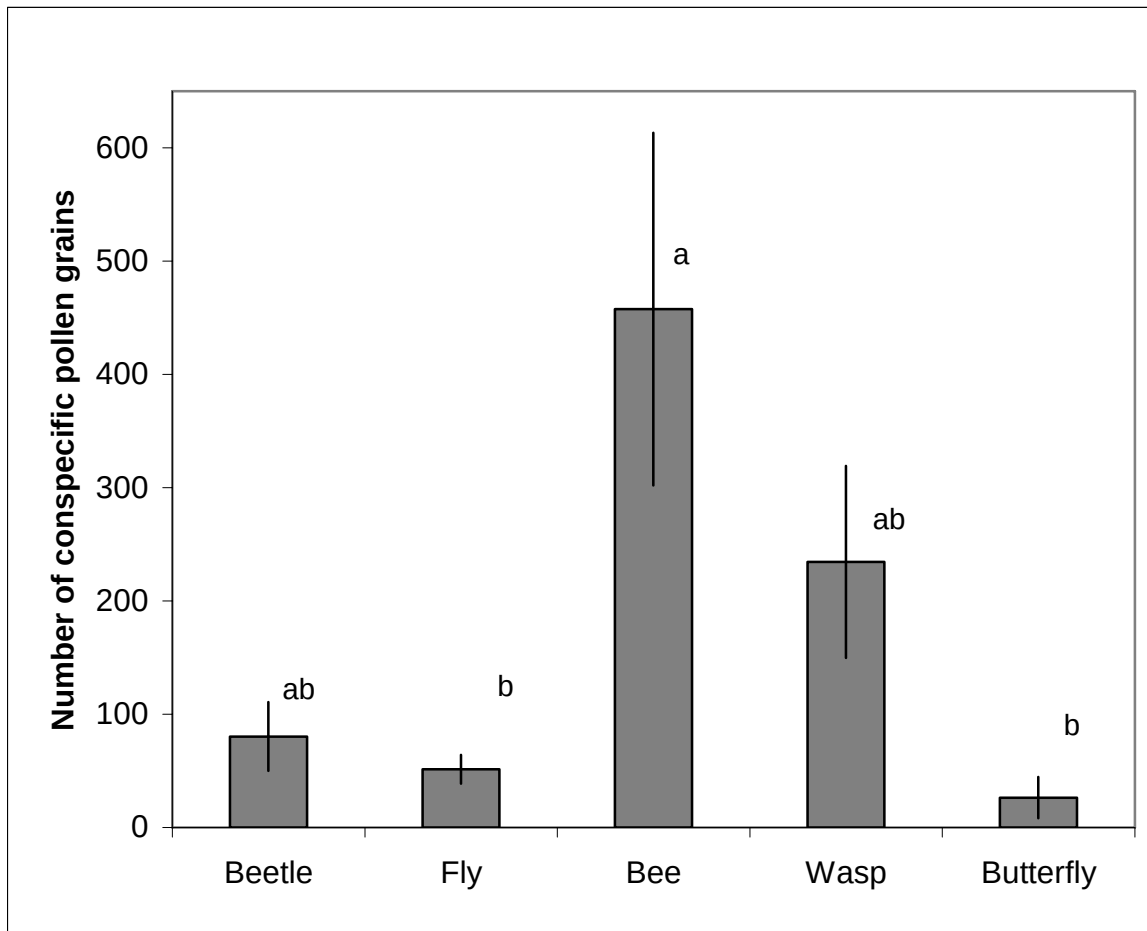
		Degree of Generalization	Log number of conspecific pollen	Proportion of conspecific pollen	Log number of foreign pollen	Number of foreign pollen morpho-types
Log number of conspecific pollen	r P value	0.019 0.801				
Proportion of conspecific pollen	r P value	0.092 0.184	0.467 <.001			
Log number of foreign pollen	r P value	0.02 0.788	0.603 <0.01*	0.069 0.355		
Number of foreign pollen morpho- types	r P value	-0.017 0.808	0.49 <.001	0.134 0.052	0.745 <.001	0.745 <.001
Log total number of pollen grains	r P value	0.067 0.353	0.898 <.001	0.383 <.001	0.865 <.001	0.669 <.001

Figure 3.1



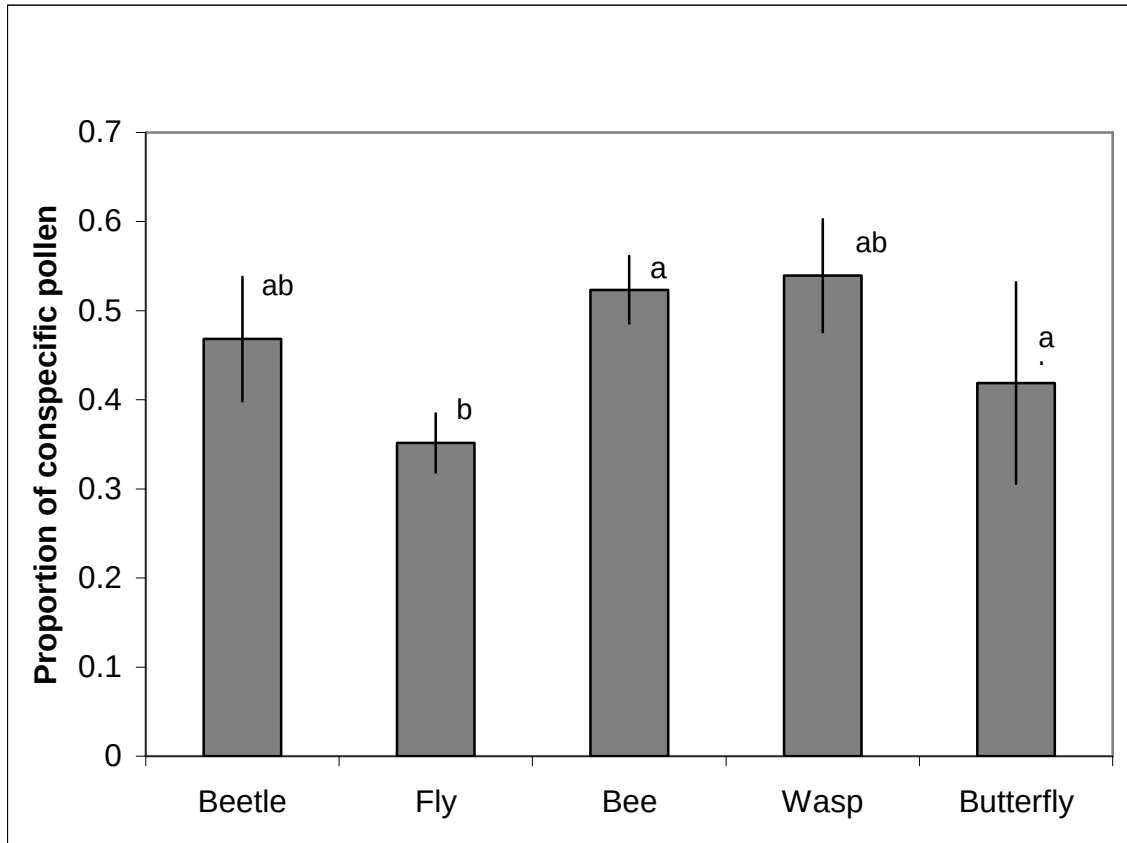
Mean ($\pm$ s. e.) number of total pollen grains carried by the different insect pollinator groups. Groups with the same small letters above the bar are not statistically different from each other based on the analysis of log-transformed values (see Table 3.1).

Figure 3.2



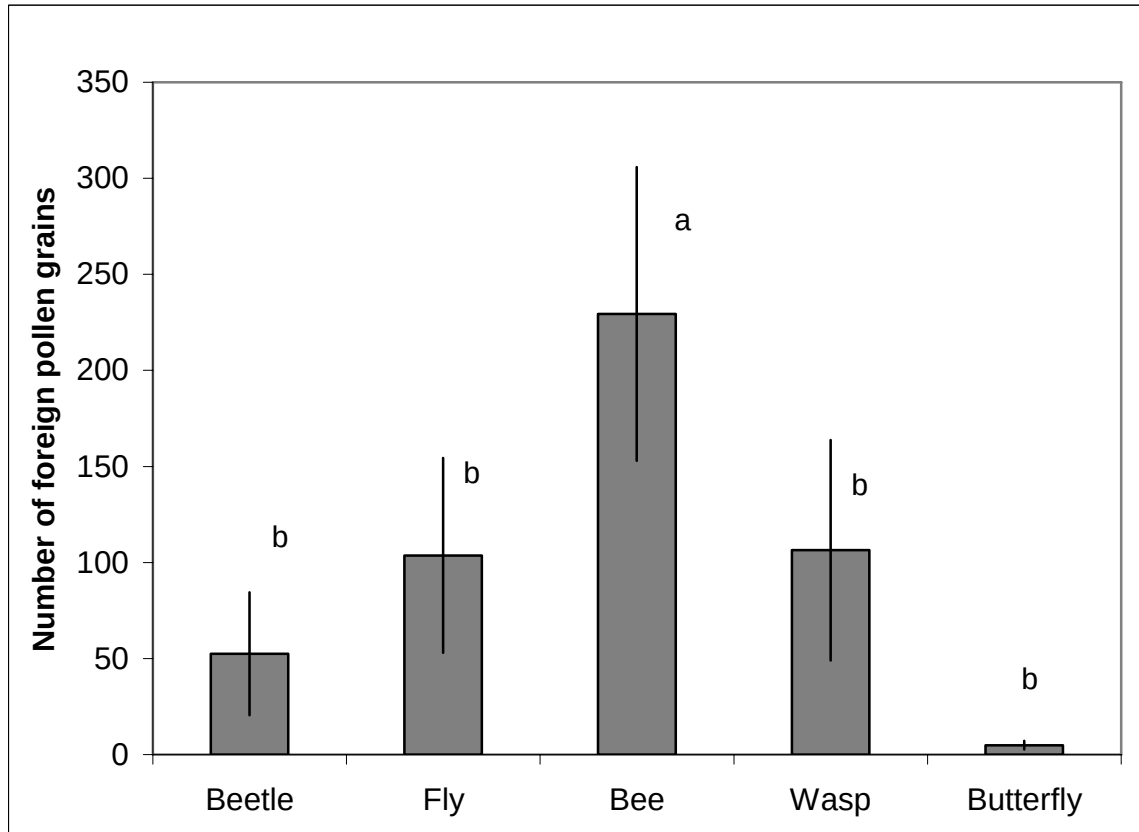
Mean ($\pm$ s. e.) number of conspecific pollen grains carried by the different insect pollinator groups. Groups with the same small letter above the bar are not statistically different from each other based on the analysis of log-transformed values (see Table 3.2). Wasps and beetles (ab) are not statistically different from either bees (a) or flies and butterflies (b).

Figure 3.3



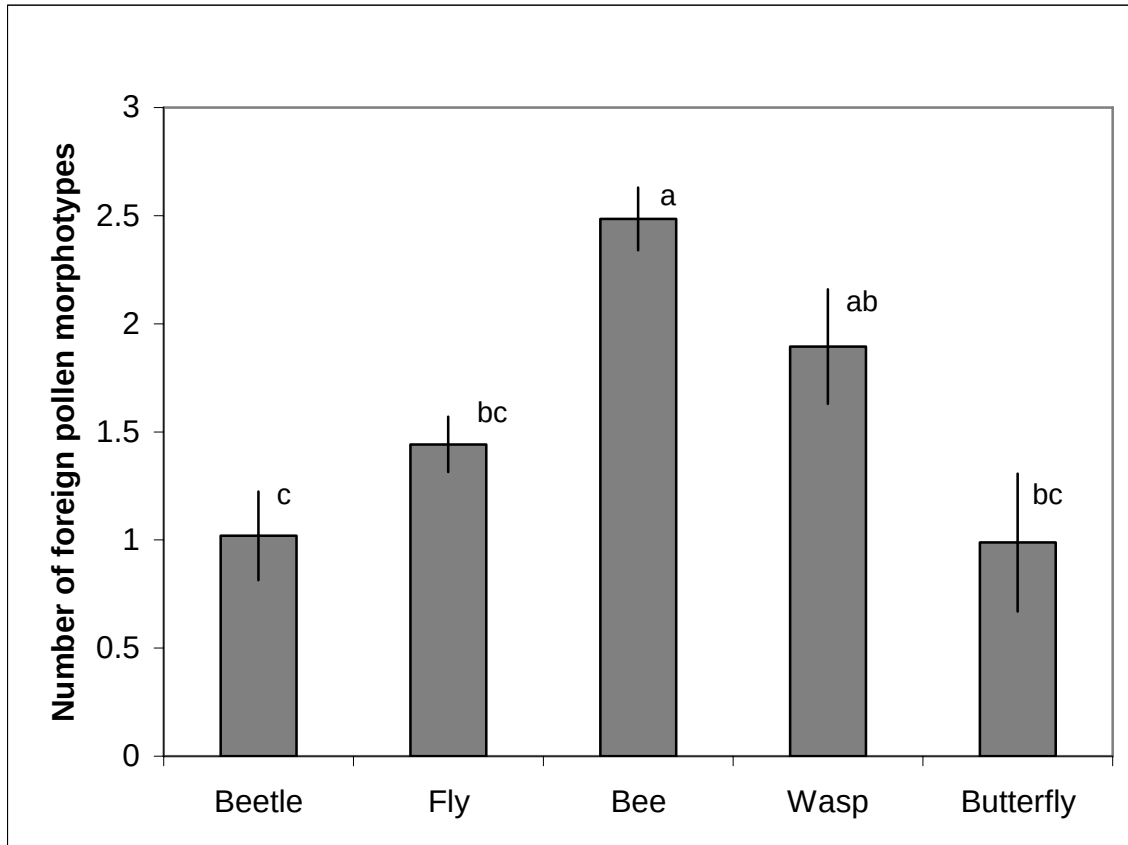
Mean ($\pm$ s. e.) proportion of conspecific pollen carried by insect species belonging to the different insect pollinator groups. Groups with the same small letters above the bar are not statistically different from each other (see Table 3.3). Bees (a) and flies (b) are the only insect groups statistically different from each other; wasps, butterflies and beetles (ab) do not differ from any group.

Figure 3.4



Mean ($\pm$ s. e.) number of foreign pollen carried by the different insect pollinator groups. Groups with the same small letters above the bars are not statistically different from each other based on the analysis of log-transformed values (see Table 3.4).

Figure 3.5



Mean ($\pm$ s. e.) number of distinct foreign pollen morphotypes carried by the different insect pollinator groups. Groups with the same small letters above the bars are not statistically different (see Table 3.5). Groups with multiple small letters are not different from groups with any of the letters above the bars.

CONCLUSIONS TO THE DISSERTATION

This study joins several other recent attempts to elucidate the structure and topology in plant-pollinator assemblages. Until recently such analyses would have been extremely difficult to carry out, and studies of entire assemblages or communities were often limited to lists of pairwise interactions. Large and complex systems however can now be readily described within the context of interaction networks (Stogatz 2000). These methodological advancements have encouraged researchers to collect, compile (e.g. Interaction Web Database at the National Center for Ecological Analysis and Synthesis), and analyze various properties of mutualistic interaction networks, because the patterns can be more thoroughly explored and compared with theoretical expectations (e.g., Bascompte et al. 2003, Vázquez and Aizen 2003, 2004, Jordano et al. 2003, 2004). Given the new tools and datasets available to biologists, it is now becoming apparent that plant-pollinator networks do not conform to traditional views regarding the specificity of plant-pollinator relationships, and this recognition is likely to have important implications for our understanding of floral evolution and angiosperm diversification.

The ecological patterns I present here do not meet the assumptions or expectations of the traditional view of pollination biology. The pollination syndrome paradigm assumes that plant-pollinator mutualisms are specialized, such that each plant species should be visited, and pollinated, by a small number of related species that it coevolved with. However, the network analyses I performed suggest that most plant and pollinator species interact with a diverse set of generalist partners. It is likely that species abundance is a major factor influencing community structure and the degree of

generalization; the more abundant a species is the great opportunity it has to interact with other mutualistic species (Dupont et al. 2003, Vázquez and Aizen 2003). Although other recent studies have also reported generalized plant-pollinator interaction networks (e.g., Waser et al. 1996, Memmott 1999, Bascompte et al. 2003, Dupont et al. 2003, Jordano et al. 2003, Vázquez and Aizen 2003) this is the first community-level survey to document that most flower visitors also carry pollen from the plants they visit and that estimates of pollinator “quantity” and “quality” are positively associated with each other. This suggests that interaction networks based on animal visitation patterns serve as good indicator of the true pollination webs, and thus that most plant species interact with generalist partners, and not with specialized pollinators. The inconsistency between generalized mutualistic interactions and presumably specialized coevolutionary process is problematic, and suggests that biologists need to reevaluate the ubiquity of the pollination syndrome hypothesis and its corollaries (Aigner 2001).

In addition, the expectation that floral trait combinations are good predictors of the types of visitors was not met; the pollination syndromes failed to predict the most frequently observed pollinator for most plant species. This is because the idealized syndromes themselves are not always phenotypically distinct from each other, and many of the traits used to place plants into syndromes are probably not equally important to pollinators. This highlights the danger of trying to predict the mode of pollination based on floral traits alone. Rather than rely on archetypal floral descriptions to try to explain how communities are structured and how plants and pollinators should interact with each other, biologists should turn their attention to functional floral and pollinator

characteristics, which determine or limit access to floral rewards and the value of those rewards to different potential visitors. Recent findings corroborate the idea that accessibility is more important in pollination systems relative to signaling traits such as color or scent type (Muchhala 2003). For example, long narrow flowers can prevent insects with a short feeding apparatus from reaching nectar, but will not exclude butterflies, hawkmoths or birds with longer mouthparts. Animals are opportunistic by nature; if they are not mechanically restricted from the floral reward they will most likely take it, unless the amount is too small for it to be profitable. Morphological characteristics that determine which animals can reach floral rewards are likely to be under strong selection to exclude “floral thieves” and increase the relative effectiveness of true pollinators. Despite the importance of animal and flower phenotype in structuring plant-pollinator networks, the biological attributes responsible for organizing mutualistic communities remain relatively unexplored (Jordano et al. 2003).

Although network analyses of mutualistic communities provide us with a “template” of how plants and animals link to one another, they do not reveal the characteristics that plant and pollinator species possess. For example, do plants and insects that interact frequently with one another possess functionally corresponding phenotypic traits? Or across communities, are there repeatable generalist plant and pollinator morphologies? By incorporating functional characteristics, such as corolla aperture, insect body size, and length of insect feeding apparatus into the analysis of mutualistic communities, it may be possible in the near future to link phenotypes with observed interactions and degree of ecological generalization. The implementation of

techniques not typically used in pollination biology, such as morphometrics, which is the study of the shapes of morphological structures and its covariation with other traits (Adams et al. 2004), hold great promise in this regard. Such techniques might be useful for identifying not only those flower visitors that are effective at removing and depositing pollen, but also which pollinator species are capable of exerting selection on the floral phenotype. Given the structure and topology of plant-pollinator communities it appears that the ecological conditions required for pollinator-mediated selection to take place under the traditional view of floral evolution would rarely be met for most plant species in most years. Ultimately biologists should attempt to analyze the shapes of pollinator bodies and floral structures for entire plant-pollinator assemblages in order to fully understand the mechanisms structuring plant-pollinator interaction networks and how floral evolution might occur in generalized pollination systems.

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APPENDICES

Appendix 1

Floral descriptions of the Bluff Mesa and Virginia Basin plant assemblages based on their the presence (1) or absence (0) of 40 floral characteristics used in the assessment of pollination syndromes (e.g. Faegri and van der Pijl 1966, see Ollerton and Watts 2000).

Bluff Mesa Plant Assemblage		Flower Shape						
Species	Family	Trap	Open	Bell	Brush	Gullet	Flag	Tube
<i>Heracleum lanatum</i>	Apiaceae	0	1	0	1	0	0	0
<i>Perideridia parishii</i>	Apiaceae	0	1	0	1	0	0	0
<i>Sphenosciadium capitellatum</i>	Apiaceae	0	1	0	1	0	0	0
<i>Apocynum androsaemifolium</i>	Apocynaceae	0	0	1	0	0	0	0
<i>Achillea millefolium</i>	Asteraceae	0	0	0	1	0	0	1
<i>Arnica chamissonis</i>	Asteraceae	0	0	0	1	0	0	1
<i>Aster occidentalis</i>	Asteraceae	0	0	0	1	0	0	1
<i>Chamomilla suaveolens</i>	Asteraceae	0	0	0	1	0	0	1
<i>Cirsium tioganum</i>	Asteraceae	0	0	0	1	0	0	1
<i>Erigeron divergens</i>	Asteraceae	0	0	0	1	0	0	1
<i>Eriophyllum lanatum</i>	Asteraceae	0	0	0	1	0	0	1
<i>Madia elegans</i>	Asteraceae	0	1	0	0	0	0	0
<i>Madia glomerata</i>	Asteraceae	0	0	0	1	0	0	1
<i>Taraxacum officinale</i>	Asteraceae	0	0	0	1	0	0	1
<i>Tragopogon dubius</i>	Asteraceae	0	0	0	1	0	0	1
<i>Arabis holboellii</i>	Brassicaceae	0	0	0	0	0	0	1
<i>Erysimum capitatum</i>	Brassicaceae	0	0	0	0	0	0	1
<i>Lepidium virginicum</i>	Brassicaceae	0	1	0	0	0	0	0
<i>Symphoricarpos rotundifolius</i>	Caprifoliaceae	0	0	1	0	0	0	0
<i>Silene verecunda platyota</i>	Caryophyllaceae	0	0	1	0	0	0	0
<i>Spergularia rubra</i>	Caryophyllaceae	0	1	0	0	0	0	0
<i>Stellaria crispa</i>	Caryophyllaceae	0	1	0	0	0	0	0
<i>Hypericum anagalloides</i>	Clusiaceae	0	1	0	0	0	0	0
<i>Arctostaphylos sp.</i>	Ericaceae	0	0	0	0	0	0	1
<i>Lotus nevadensis</i>	Fabaceae	0	0	0	0	0	1	0
<i>Lotus oblongifolius</i>	Fabaceae	0	0	0	0	0	1	0
<i>Lotus pershianus</i>	Fabaceae	0	0	0	0	0	1	0
<i>Lupinus andersonii</i>	Fabaceae	0	0	0	0	0	1	0
<i>Lupinus latifolius</i>	Fabaceae	0	0	0	0	0	1	0
<i>Lupinus lepidus</i>	Fabaceae	0	0	0	0	0	1	0
<i>Lupinus polyphyllus</i>	Fabaceae	0	0	0	0	0	1	0
<i>Trifolium longipes</i>	Fabaceae	0	0	0	0	0	1	0
<i>Geranium richardsonii</i>	Geraniaceae	0	1	0	0	0	0	0
<i>Ribes nevadensis</i>	Grossulariaceae	0	0	0	0	0	0	1
<i>Phacelia imbricata</i>	Hydrophyllaceae	0	0	1	0	0	0	0

Appendix 1

Bluff Mesa Plant Assemblage	Symmetry	Size		Flower Orientation		
Species	Zygomorphic	Medium/ Small	Mechanically Strong	Pendant	Upright	Horizontal
<i>Heracleum lanatum</i>	0	1	0	0	1	0
<i>Perideridia parishii</i>	0	1	0	0	1	0
<i>Sphenosciadium capitellatum</i>	0	1	0	1	1	1
<i>Apocynum androsaemifolium</i>	0	1	0	1	0	1
<i>Achillea millefolium</i>	0	1	0	0	1	0
<i>Arnica chamissonis</i>	0	1	0	0	1	0
<i>Aster occidentalis</i>	0	1	0	0	1	0
<i>Chamomilla suaveolens</i>	0	1	0	0	1	1
<i>Cirsium tioganum</i>	0	1	0	0	1	0
<i>Erigeron divergens</i>	0	1	0	0	1	0
<i>Eriophyllum lanatum</i>	0	1	0	0	1	0
<i>Madia elegans</i>	0	1	0	0	1	0
<i>Madia glomerata</i>	0	1	0	0	1	0
<i>Taraxacum officinale</i>	0	1	0	0	1	0
<i>Tragopogon dubius</i>	0	0	0	0	1	0
<i>Arabis holboellii</i>	0	1	0	1	0	0
<i>Erysimum capitatum</i>	0	1	0	0	1	0
<i>Lepidium virginicum</i>	0	1	0	0	1	0
<i>Symphoricarpos rotundifolius</i>	0	1	0	1	0	0
<i>Silene verecunda platyota</i>	0	1	0	0	1	0
<i>Spergularia rubra</i>	0	1	0	0	1	0
<i>Stellaria crispa</i>	0	1	0	0	1	0
<i>Hypericum anagalloides</i>	0	1	0	0	1	0
<i>Arctostaphylos sp.</i>	0	1	0	1	0	0
<i>Lotus nevadensis</i>	1	1	1	0	0	1
<i>Lotus oblongifolius</i>	1	1	1	0	0	1
<i>Lotus pershianus</i>	1	1	0	0	1	1
<i>Lupinus andersonii</i>	1	1	1	0	0	1
<i>Lupinus latifolius</i>	1	1	1	0	0	1
<i>Lupinus lepidus</i>	1	1	1	0	0	1
<i>Lupinus polyphyllus</i>	1	1	1	0	0	1
<i>Trifolium longipes</i>	1	1	1	0	1	0
<i>Geranium richardsonii</i>	0	1	0	0	1	0
<i>Ribes nevadensis</i>	0	1	0	1	0	1
<i>Phacelia imbricata</i>	0	1	0	1	1	1

Appendix 1

Bluff Mesa Plant Assemblage	Anthers		Tube Morphology				Time of Opening
Species	Stiff	Exposed	Narrow	Wide	Short	Long	Day
<i>Heracleum lanatum</i>	0	1	0	0	0	0	1
<i>Perideridia parishii</i>	0	1	0	0	0	0	1
<i>Sphenosciadium capitellatum</i>	0	1	0	0	0	0	1
<i>Apocynum androsaemifolium</i>	0	0	0	0	0	0	0
<i>Achillea millefolium</i>	0	1	1	0	1	0	1
<i>Arnica chamissonis</i>	0	1	1	0	1	0	1
<i>Aster occidentalis</i>	0	1	1	0	1	0	1
<i>Chamomilla suaveolens</i>	0	0	1	0	1	0	0
<i>Cirsium tioganum</i>	0	1	1	0	0	1	1
<i>Erigeron divergens</i>	0	1	1	0	1	0	1
<i>Eriophyllum lanatum</i>	0	1	1	0	1	0	1
<i>Madia elegans</i>	0	0	1	0	1	0	1
<i>Madia glomerata</i>	0	1	1	0	1	0	1
<i>Taraxacum officinale</i>	0	1	1	0	1	0	1
<i>Tragopogon dubius</i>	0	1	1	0	1	0	1
<i>Arabis holboellii</i>	0	0	1	0	1	0	1
<i>Erysimum capitatum</i>	0	1	1	0	0	1	1
<i>Lepidium virginicum</i>	0	1	0	0	0	0	1
<i>Symphoricarpos rotundifolius</i>	0	0	0	0	0	0	1
<i>Silene verecunda platyota</i>	0	1	0	1	0	1	1
<i>Spergularia rubra</i>	0	1	0	0	0	0	1
<i>Stellaria crispa</i>	1	0	0	0	0	0	1
<i>Hypericum anagalloides</i>	0	1	0	0	0	0	1
<i>Arctostaphylos sp.</i>	0	0	1	0	1	0	1
<i>Lotus nevadensis</i>	1	0	0	0	0	0	1
<i>Lotus oblongifolius</i>	1	0	0	0	0	0	1
<i>Lotus pershianus</i>	0	0	0	0	0	0	1
<i>Lupinus andersonii</i>	1	0	0	0	0	0	1
<i>Lupinus latifolius</i>	1	0	0	0	0	0	1
<i>Lupinus lepidus</i>	1	0	0	0	0	0	1
<i>Lupinus polyphyllus</i>	1	0	0	0	0	0	1
<i>Trifolium longipes</i>	1	0	0	0	0	0	1
<i>Geranium richardsonii</i>	0	1	0	0	0	0	1
<i>Ribes nevadensis</i>	0	0	0	1	1	0	1
<i>Phacelia imbricata</i>	0	1	0	1	1	0	1

Appendix 1

Bluff Mesa Plant Assemblage	Odor Strength		Scent Type					
Species	Strong	None	Sweet	Fruity	Fresh	Musky	Sour	Decaying
<i>Heracleum lanatum</i>	0	0	0	0	0	1	0	1
<i>Perideridia parishii</i>	0	1	0	0	0	0	0	0
<i>Sphenosciadium capitellatum</i>	0	0	0	0	0	1	0	0
<i>Apocynum androsaemifolium</i>	0	0	1	1	0	0	0	0
<i>Achillea millefolium</i>	1	0	0	0	0	0	1	0
<i>Arnica chamissonis</i>	0	0	0	0	1	0	0	0
<i>Aster occidentalis</i>	0	0	1	0	0	1	0	0
<i>Chamomilla suaveolens</i>	0	0	1	1	0	0	0	0
<i>Cirsium tioganum</i>	0	0	1	0	0	0	0	0
<i>Erigeron divergens</i>	0	1	0	0	0	0	0	0
<i>Eriophyllum lanatum</i>	1	0	0	0	0	1	0	0
<i>Madia elegans</i>	0	0	0	0	0	0	1	0
<i>Madia glomerata</i>	1	0	0	0	0	1	1	0
<i>Taraxacum officinale</i>	0	0	0	0	1	0	0	0
<i>Tragopogon dubius</i>	0	1	0	0	0	0	0	0
<i>Arabis holboellii</i>	0	1	0	0	0	0	0	0
<i>Erysimum capitatum</i>	0	1	0	0	0	0	0	0
<i>Lepidium virginicum</i>	0	0	0	0	1	0	0	0
<i>Symphoricarpos rotundifolius</i>	0	0	0	0	1	0	0	0
<i>Silene verecunda platyota</i>	0	0	0	0	0	1	0	0
<i>Spergularia rubra</i>	0	1	0	0	0	0	0	0
<i>Stellaria crispa</i>	0	0	0	0	0	1	0	0
<i>Hypericum anagalloides</i>	0	0	0	0	1	0	0	0
<i>Arctostaphylos sp.</i>	0	1	0	0	0	0	0	0
<i>Lotus nevadensis</i>	0	1	0	0	0	0	0	0
<i>Lotus oblongifolius</i>	0	1	0	0	0	0	0	0
<i>Lotus pershianus</i>	0	1	0	0	0	0	0	0
<i>Lupinus andersonii</i>	0	0	0	0	1	0	0	0
<i>Lupinus latifolius</i>	1	0	1	1	0	0	0	0
<i>Lupinus lepidus</i>	0	0	1	0	1	0	0	0
<i>Lupinus polyphyllus</i>	1	0	1	1	0	0	0	0
<i>Trifolium longipes</i>	0	0	1	0	1	0	0	0
<i>Geranium richardsonii</i>	0	1	0	0	0	0	0	0
<i>Ribes nevadensis</i>	0	0	0	0	1	0	0	0
<i>Phacelia imbricata</i>	0	0	1	0	0	0	0	0

Appendix 1

Bluff Mesa Plant Assemblage	Color Brightness	Color						
Species	Vivid	Brown	White	Red	Green	Yellow	Blue	Purple
<i>Heracleum lanatum</i>	0	0	1	0	0	0	0	0
<i>Perideridia parishii</i>	0	0	1	0	0	0	0	0
<i>Sphenosciadium capitellatum</i>	0	0	1	0	0	0	0	0
<i>Apocynum androsaemifolium</i>	0	0	1	1	0	0	0	0
<i>Achillea millefolium</i>	0	0	1	0	0	0	0	0
<i>Arnica chamissonis</i>	0	0	0	0	0	1	0	0
<i>Aster occidentalis</i>	1	0	0	0	0	1	0	1
<i>Chamomilla suaveolens</i>	0	0	0	0	1	1	0	0
<i>Cirsium tioganum</i>	0	0	0	0	0	0	0	1
<i>Erigeron divergens</i>	0	0	1	0	0	0	0	1
<i>Eriophyllum lanatum</i>	0	0	0	0	0	1	0	0
<i>Madia elegans</i>	1	0	0	0	0	1	0	0
<i>Madia glomerata</i>	1	0	0	0	0	1	0	0
<i>Taraxacum officinale</i>	1	0	0	0	0	1	0	0
<i>Tragopogon dubius</i>	1	0	0	0	0	1	0	0
<i>Arabis holboellii</i>	0	0	1	0	0	0	0	0
<i>Erysimum capitatum</i>	1	0	0	0	0	1	0	0
<i>Lepidium virginicum</i>	0	0	1	0	1	0	0	0
<i>Symphoricarpos rotundifolius</i>	0	0	1	1	0	0	0	0
<i>Silene verecunda platyota</i>	0	0	1	1	0	0	0	0
<i>Spergularia rubra</i>	0	0	1	0	0	0	0	0
<i>Stellaria crispa</i>	0	0	1	0	0	0	0	0
<i>Hypericum anagalloides</i>	0	0	0	0	0	1	0	0
<i>Arctostaphylos sp.</i>	0	0	1	0	0	0	0	0
<i>Lotus nevadensis</i>	0	0	0	0	0	1	0	0
<i>Lotus oblongifolius</i>	0	0	0	0	0	1	0	0
<i>Lotus pershianus</i>	0	0	1	0	0	0	0	0
<i>Lupinus andersonii</i>	0	1	1	0	0	1	0	0
<i>Lupinus latifolius</i>	0	0	1	1	0	0	0	1
<i>Lupinus lepidus</i>	0	1	0	0	0	0	1	1
<i>Lupinus polyphyllus</i>	0	0	0	0	0	0	1	1
<i>Trifolium longipes</i>	0	0	1	1	0	0	0	1
<i>Geranium richardsonii</i>	0	0	1	1	0	0	0	0
<i>Ribes nevadensis</i>	0	0	1	1	0	0	0	0
<i>Phacelia imbricata</i>	0	0	1	1	0	0	0	0

Appendix 1

Bluff Mesa Plant Assemblage	Nectar		Nectar Volume	
Species	Guides	Present	Abundant	Moderate
<i>Heracleum lanatum</i>	0	1	0	0
<i>Perideridia parishii</i>	0	1	0	0
<i>Sphenosciadium capitellatum</i>	0	1	0	0
<i>Apocynum androsaemifolium</i>	1	1	0	0
<i>Achillea millefolium</i>	0	1	0	0
<i>Arnica chamissonis</i>	0	1	0	1
<i>Aster occidentalis</i>	1	1	0	0
<i>Chamomilla suaveolens</i>	0	0	0	0
<i>Cirsium tioganum</i>	0	1	0	0
<i>Erigeron divergens</i>	0	1	0	0
<i>Eriophyllum lanatum</i>	0	1	0	0
<i>Madia elegans</i>	1	1	0	0
<i>Madia glomerata</i>	0	1	0	0
<i>Taraxacum officinale</i>	0	1	0	0
<i>Tragopogon dubius</i>	0	1	0	1
<i>Arabis holboellii</i>	0	1	0	0
<i>Erysimum capitatum</i>	1	1	0	1
<i>Lepidium virginicum</i>	0	1	0	0
<i>Symphoricarpos rotundifolius</i>	0	1	0	0
<i>Silene verecunda platyota</i>	1	1	0	1
<i>Spergularia rubra</i>	1	1	0	0
<i>Stellaria crispa</i>	0	1	0	0
<i>Hypericum anagalloides</i>	0	1	0	0
<i>Arctostaphylos sp.</i>	0	1	0	0
<i>Lotus nevadensis</i>	1	1	0	0
<i>Lotus oblongifolius</i>	1	1	0	0
<i>Lotus pershianus</i>	1	1	0	0
<i>Lupinus andersonii</i>	1	1	0	0
<i>Lupinus latifolius</i>	1	1	0	1
<i>Lupinus lepidus</i>	1	1	0	1
<i>Lupinus polyphyllus</i>	1	1	0	1
<i>Trifolium longipes</i>	0	1	0	0
<i>Geranium richardsonii</i>	1	1	0	1
<i>Ribes nevadensis</i>	1	1	0	0
<i>Phacelia imbricata</i>	0	1	0	0

Appendix 1

Bluff Mesa Plant Assemblage		Flower Shape						
Species	Family	Trap	Open	Bell	Brush	Gullet	Flag	Tube
<i>Iris hartwegii</i>	Iridaceae	0	0	0	0	1	0	0
<i>Monardella linoides</i>	Lamiaceae	0	0	0	0	0	0	1
<i>Stachys albens</i>	Lamiaceae	0	0	0	0	1	0	0
<i>Lilium parryi</i>	Liliaceae	0	0	1	0	0	0	0
<i>Sidalcea pedata</i>	Malvaceae	0	1	0	0	0	0	0
<i>Veratrum californicum</i>	Melanthraceae	0	1	0	0	0	0	0
<i>Epilobium angustifolium</i>	Onagraceae	0	1	0	0	0	0	0
<i>Epilobium ciliatum</i>	Onagraceae	0	0	0	0	0	0	1
<i>Epilobium glaberrimum</i>	Onagraceae	0	0	0	0	0	0	1
<i>Gayophytum diffusum</i>	Onagraceae	0	1	0	0	0	0	0
<i>Epipactis gigantea</i>	Orchidaceae	0	0	0	0	1	0	0
<i>Plantanthera leucostachys</i>	Orchidaceae	0	0	0	0	0	0	1
<i>Collomia linearis</i>	Polemoniaceae	0	0	0	0	0	0	1
<i>Polygonum bistoroides</i>	Polygoniaceae	0	1	0	1	0	0	0
<i>Calyptridium umbellatum</i>	Portulacaceae	0	1	0	1	0	0	0
<i>Aquilegia formosa</i>	Ranunculaceae	0	0	0	0	0	0	1
<i>Ranunculus alismaefolius</i>	Ranunculaceae	0	1	0	0	0	0	0
<i>Thalictrum fendleri</i>	Ranunculaceae	0	1	0	0	0	0	0
<i>Horkelia rydbergii</i>	Rosaceae	0	1	0	0	0	0	0
<i>Potentilla anserina</i>	Rosaceae	0	1	0	0	0	0	0
<i>Potentilla glandulosa</i>	Rosaceae	0	1	0	0	0	0	0
<i>Potentilla gracilis</i>	Rosaceae	0	1	0	0	0	0	0
<i>Prunus virginiana</i>	Rosaceae	0	1	0	0	0	0	0
<i>Rosa californica</i>	Rosaceae	0	1	0	0	0	0	0
<i>Kellogia galioides</i>	Rubiaceae	0	0	0	0	0	0	1
<i>Castilleja miniata</i>	Scrophulariaceae	0	0	0	1	0	0	1
<i>Mimulus guttatus</i>	Scrophulariaceae	0	0	0	0	1	0	0
<i>Mimulus moschatus</i>	Scrophulariaceae	0	0	0	0	1	0	0
<i>Pedicularis semibarbarata</i>	Scrophulariaceae	0	0	0	0	1	0	0
<i>Penstemon caesius</i>	Scrophulariaceae	0	0	0	0	0	0	1
<i>Penstemon grinnellii</i>	Scrophulariaceae	0	0	0	0	1	0	0
<i>Penstemon labrosus</i>	Scrophulariaceae	0	0	0	0	0	0	1

Appendix 1

Bluff Mesa Plant Assemblage	Symmetry	Size		Flower Orientation		
Species	Zygomorphic	Medium/ Small	Mechanically Strong	Pendant	Upright	Horizontal
<i>Iris hartwegii</i>	0	0	0	0	0	1
<i>Monardella linoides</i>	1	1	0	0	1	0
<i>Stachys albens</i>	1	1	0	0	0	1
<i>Lilium parryi</i>	0	0	1	1	0	1
<i>Sidalcea pedata</i>	0	1	0	0	1	1
<i>Veratrum californicum</i>	0	1	0	0	0	1
<i>Epilobium angustifolium</i>	0	1	0	0	0	1
<i>Epilobium ciliatum</i>	0	1	0	0	1	0
<i>Epilobium glaberrimum</i>	0	1	0	1	0	1
<i>Gayophytum diffusum</i>	0	1	0	0	1	0
<i>Epipactis gigantea</i>	1	1	0	0	0	1
<i>Plantanthera leucostachys</i>	1	1	0	0	1	0
<i>Collomia linearis</i>	0	1	0	0	1	0
<i>Polygonum bistoroides</i>	0	1	0	0	1	1
<i>Calyptridium umbellatum</i>	0	1	0	0	1	0
<i>Aquilegia formosa</i>	0	0	0	1	0	0
<i>Ranunculus alismaefolius</i>	0	1	0	0	1	0
<i>Thalictrum fendleri</i>	0	1	0	1	0	0
<i>Horkelia rydbergii</i>	0	1	0	0	1	0
<i>Potentilla anserina</i>	0	1	0	0	1	0
<i>Potentilla glandulosa</i>	0	1	0	0	0	1
<i>Potentilla gracilis</i>	0	1	0	0	1	0
<i>Prunus virginiana</i>	0	1	0	0	1	0
<i>Rosa californica</i>	0	1	0	0	1	0
<i>Kellogia galioides</i>	0	1	0	0	1	0
<i>Castilleja miniata</i>	0	1	0	0	1	0
<i>Mimulus guttatus</i>	1	0	1	0	1	0
<i>Mimulus moschatus</i>	1	1	1	0	1	0
<i>Pedicularis semibarbarata</i>	1	1	0	1	0	1
<i>Penstemon caesius</i>	1	1	0	0	0	1
<i>Penstemon grinnellii</i>	1	0	0	0	1	1
<i>Penstemon labrosus</i>	1	0	0	1	0	1

Appendix 1

Bluff Mesa Plant Assemblage	Anthers		Tube Morphology				Time of Opening
Species	Stiff	Exposed	Narrow	Wide	Short	Long	Day
<i>Iris hartwegii</i>	1	1	0	0	0	0	1
<i>Monardella linoides</i>	0	1	1	0	1	0	1
<i>Stachys albens</i>	0	1	0	0	0	0	1
<i>Lilium parryi</i>	1	1	0	0	0	0	0
<i>Sidalcea pedata</i>	1	1	0	0	0	0	1
<i>Veratrum californicum</i>	0	1	0	0	0	0	1
<i>Epilobium angustifolium</i>	0	1	0	0	0	0	1
<i>Epilobium ciliatum</i>	0	0	0	1	1	0	1
<i>Epilobium glaberrimum</i>	0	0	0	1	1	0	1
<i>Gayophytum diffusum</i>	0	1	0	0	0	0	1
<i>Epipactis gigantea</i>	1	0	0	0	0	0	1
<i>Plantanthera leucostachys</i>	0	0	1	0	0	1	1
<i>Collomia linearis</i>	0	0	1	0	1	0	1
<i>Polygonum bistoroides</i>	0	1	0	0	0	0	1
<i>Calyptridium umbellatum</i>	0	0	0	0	0	0	1
<i>Aquilegia formosa</i>	1	1	0	1	0	1	1
<i>Ranunculus alismaefolius</i>	0	1	0	0	0	0	1
<i>Thalictrum fendleri</i>	0	1	0	0	0	0	1
<i>Horkelia rydbergii</i>	0	1	0	0	0	0	1
<i>Potentilla anserina</i>	0	1	0	0	0	0	1
<i>Potentilla glandulosa</i>	0	1	0	0	0	0	1
<i>Potentilla gracilis</i>	0	1	0	0	0	0	1
<i>Prunus virginiana</i>	0	1	0	0	0	0	1
<i>Rosa californica</i>	0	1	0	0	0	0	1
<i>Kellogia galioides</i>	0	1	1	0	1	0	1
<i>Castilleja miniata</i>	1	0	1	0	0	1	1
<i>Mimulus guttatus</i>	1	0	0	0	0	0	1
<i>Mimulus moschatus</i>	0	0	0	0	0	0	1
<i>Pedicularis semibarbarata</i>	0	1	0	0	0	0	1
<i>Penstemon caesius</i>	0	0	0	1	0	1	1
<i>Penstemon grinnellii</i>	1	0	0	0	0	0	1
<i>Penstemon labrosus</i>	1	1	0	1	0	1	1

Appendix 1

Bluff Mesa Plant Assemblage	Odor Strength		Scent Type					
Species	Strong	None	Sweet	Fruity	Fresh	Musky	Sour	Decaying
<i>Iris hartwegii</i>	0	0	0	0	1	0	0	0
<i>Monardella linoides</i>	1	0	0	0	0	1	0	0
<i>Stachys albens</i>	0	0	0	0	0	1	1	0
<i>Lilium parryi</i>	1	0	1	0	1	1	0	0
<i>Sidalcea pedata</i>	0	0	0	0	0	1	0	0
<i>Veratrum californicum</i>	0	0	0	0	1	0	0	0
<i>Epilobium angustifolium</i>	0	0	0	0	0	1	1	0
<i>Epilobium ciliatum</i>	0	1	0	0	0	0	0	0
<i>Epilobium glaberrimum</i>	0	1	0	0	0	0	0	0
<i>Gayophytum diffusum</i>	0	1	0	0	0	0	0	0
<i>Epipactis gigantea</i>	0	0	0	0	1	0	0	0
<i>Plantanthera leucostachys</i>	1	0	1	0	0	1	0	0
<i>Collomia linearis</i>	0	0	0	0	0	1	1	0
<i>Polygonum bistoroides</i>	0	0	0	0	0	1	0	1
<i>Calyptridium umbellatum</i>	0	0	1	0	1	0	0	0
<i>Aquilegia formosa</i>	0	1	0	0	0	0	0	0
<i>Ranunculus alismaefolius</i>	0	1	0	0	0	0	0	0
<i>Thalictrum fendleri</i>	1	0	0	0	0	1	0	1
<i>Horkelia rydbergii</i>	0	0	0	0	0	1	0	1
<i>Potentilla anserina</i>	0	0	1	0	1	0	0	0
<i>Potentilla glandulosa</i>	0	0	0	0	0	1	0	0
<i>Potentilla gracilis</i>	0	1	0	0	0	0	0	0
<i>Prunus virginiana</i>	0	0	0	0	0	1	0	0
<i>Rosa californica</i>	0	0	1	0	1	0	0	0
<i>Kellogia galioides</i>	0	0	1	0	0	0	0	0
<i>Castilleja miniata</i>	0	1	0	0	0	0	0	0
<i>Mimulus guttatus</i>	0	1	0	0	0	0	0	0
<i>Mimulus moschatus</i>	0	1	0	0	0	0	0	0
<i>Pedicularis semibarbarata</i>	0	0	0	0	0	0	1	0
<i>Penstemon caesius</i>	0	1	0	0	0	0	0	0
<i>Penstemon grinnellii</i>	0	0	1	0	1	0	0	0
<i>Penstemon labrosus</i>	0	1	0	0	0	0	0	0

Appendix 1

Bluff Mesa Plant Assemblage	Color Brightness	Color						
Species	Vivid	Brown	White	Red	Green	Yellow	Blue	Purple
<i>Iris hartwegii</i>	0	0	1	0	0	1	1	0
<i>Monardella linoides</i>	0	0	1	0	0	0	0	1
<i>Stachys albens</i>	0	0	1	0	0	0	0	1
<i>Lilium parryi</i>	1	0	0	0	0	1	0	0
<i>Sidalcea pedata</i>	0	0	0	0	0	0	0	1
<i>Veratrum californicum</i>	0	0	1	0	1	0	0	0
<i>Epilobium angustifolium</i>	0	0	0	0	0	0	0	1
<i>Epilobium ciliatum</i>	0	0	1	0	0	0	0	0
<i>Epilobium glaberrimum</i>	0	0	1	0	0	0	0	0
<i>Gayophytum diffusum</i>	0	0	1	0	1	1	0	0
<i>Epipactis gigantea</i>	0	1	0	1	1	0	0	0
<i>Plantanthera leucostachys</i>	0	0	1	0	0	0	0	0
<i>Collomia linearis</i>	0	0	1	0	0	0	0	1
<i>Polygonum bistoroides</i>	0	0	1	0	0	0	0	0
<i>Calyptridium umbellatum</i>	0	0	1	0	0	0	0	0
<i>Aquilegia formosa</i>	0	0	0	1	0	1	0	0
<i>Ranunculus alismaefolius</i>	1	0	0	0	0	1	0	0
<i>Thalictrum fendleri</i>	0	0	1	0	1	0	0	0
<i>Horkelia rydbergii</i>	0	0	1	0	0	0	0	0
<i>Potentilla anserina</i>	0	0	0	0	0	1	0	0
<i>Potentilla glandulosa</i>	0	0	1	0	0	1	0	0
<i>Potentilla gracilis</i>	0	0	0	0	0	1	0	0
<i>Prunus virginiana</i>	0	0	1	0	0	0	0	0
<i>Rosa californica</i>	0	0	1	0	0	0	0	0
<i>Kellogia galioides</i>	0	0	1	0	0	0	0	0
<i>Castilleja miniata</i>	0	0	0	1	0	0	0	0
<i>Mimulus guttatus</i>	0	0	0	0	0	1	0	0
<i>Mimulus moschatus</i>	0	0	0	0	0	1	0	0
<i>Pedicularis semibarbarata</i>	0	1	0	0	0	1	0	1
<i>Penstemon caesius</i>	0	0	1	0	0	0	0	1
<i>Penstemon grinnellii</i>	0	0	1	0	0	0	0	1
<i>Penstemon labrosus</i>	0	0	0	1	0	0	0	0

Appendix 1

Bluff Mesa Plant Assemblage	Nectar		Nectar Volume	
Species	Guides	Present	Abundant	Moderate
<i>Iris hartwegii</i>	1	1	0	1
<i>Monardella linoides</i>	1	1	0	0
<i>Stachys albens</i>	1	1	0	0
<i>Lilium parryi</i>	0	1	1	0
<i>Sidalcea pedata</i>	1	1	0	0
<i>Veratrum californicum</i>	1	1	0	1
<i>Epilobium angustifolium</i>	1	1	0	0
<i>Epilobium ciliatum</i>	1	1	0	0
<i>Epilobium glaberrimum</i>	1	1	0	0
<i>Gayophytum diffusum</i>	1	1	0	0
<i>Epipactis gigantea</i>	1	1	0	0
<i>Plantanthera leucostachys</i>	0	1	0	1
<i>Collomia linearis</i>	1	1	0	0
<i>Polygonum bistoroides</i>	0	1	0	0
<i>Calyptridium umbellatum</i>	0	1	0	0
<i>Aquilegia formosa</i>	0	1	1	0
<i>Ranunculus alismaefolius</i>	1	1	0	0
<i>Thalictrum fendleri</i>	0	0	0	0
<i>Horkelia rydbergii</i>	0	1	0	0
<i>Potentilla anserina</i>	1	1	0	0
<i>Potentilla glandulosa</i>	0	1	0	0
<i>Potentilla gracilis</i>	1	1	0	0
<i>Prunus virginiana</i>	0	1	0	0
<i>Rosa californica</i>	0	1	0	0
<i>Kellogia galioides</i>	0	1	0	0
<i>Castilleja miniata</i>	0	1	1	0
<i>Mimulus guttatus</i>	1	1	0	1
<i>Mimulus moschatus</i>	1	1	0	0
<i>Pedicularis semibarbarata</i>	1	1	0	0
<i>Penstemon caesius</i>	1	1	0	0
<i>Penstemon grinnellii</i>	1	1	0	1
<i>Penstemon labrosus</i>	0	1	1	0

Appendix 1

Virginia Basin Plant Assemblage		Flower Shape						
Species	Family	Trap	Open	Bell	Brush	Gullet	Flag	Tube
<i>Ligusticum porteri</i>	Apiaceae	0	1	0	0	0	0	0
<i>Pseudocymopterus montanus</i>	Apiaceae	0	0	0	1	0	0	0
<i>Achillia lanulosa</i>	Asteraceae	0	0	0	0	0	0	1
<i>Agoseris aurantiaca</i>	Asteraceae	0	0	0	0	0	0	1
<i>Agoseris glauca</i>	Asteraceae	0	0	0	0	0	0	1
<i>Antennaria rosea</i>	Asteraceae	0	0	0	1	0	0	0
<i>Arnica cordifolia</i>	Asteraceae	0	0	0	0	0	0	1
<i>Arnica parryi</i>	Asteraceae	0	0	0	0	0	0	1
<i>Arnica rydbergii</i>	Asteraceae	0	0	0	0	0	0	1
<i>Cirsium scopulorum</i>	Asteraceae	0	0	0	0	0	0	1
<i>Erigeron elatior</i>	Asteraceae	0	0	0	0	0	0	1
<i>Erigeron peregrinus</i>	Asteraceae	0	1	0	0	0	0	0
<i>Erigeron speciosus</i>	Asteraceae	0	0	0	0	0	0	1
<i>Helenium hoopesii</i>	Asteraceae	0	0	1	0	0	0	0
<i>Helianthella quinquenervis</i>	Asteraceae	0	1	0	0	0	0	0
<i>Heterotheca villosa</i>	Asteraceae	0	0	0	0	0	0	1
<i>Senecio bigelovii</i>	Asteraceae	0	0	0	0	0	0	1
<i>Senecio crassulus</i>	Asteraceae	0	0	0	0	0	0	1
<i>Solidago spathulata</i>	Asteraceae	0	0	0	0	0	0	1
<i>Mertensia ciliata</i>	Boraginaceae	0	0	0	0	0	0	1
<i>Arabis drummondii</i>	Brassicaceae	0	0	0	0	0	0	1
<i>Descurainia pinnata</i>	Brassicaceae	0	0	0	0	0	0	1
<i>Lonicera involucrata</i>	Caprifoliaceae	0	0	0	0	0	0	1
<i>Arenana congesta</i>	Caryophyllaceae	0	0	0	0	0	0	1
<i>Sedum integrifolium</i>	Crassulaceae	0	1	0	0	0	0	0
<i>Sedum stenopetalum</i>	Crassulaceae	0	1	0	0	0	0	0
<i>Astragalus alpinus</i>	Fabaceae	0	0	0	0	0	1	0
<i>Lathyrus leucanthus</i>	Fabaceae	0	0	0	0	0	1	0
<i>Vicia americana</i>	Fabaceae	0	0	0	0	0	1	0
<i>Gentiana heterosepala</i>	Gentianaceae	0	0	0	0	0	0	1
<i>Gentianella amarella</i>	Gentianaceae	0	1	0	0	0	0	0
<i>Gentianella parryi</i>	Gentianaceae	0	0	1	0	0	0	0
<i>Gentianopsis detonsa</i>	Gentianaceae	0	0	0	0	0	0	1
<i>Geranium richardsonii</i>	Geraniaceae	0	0	0	0	0	0	1
<i>Hydrophyllum fendleri</i>	Hydrophyllaceae	0	1	0	0	0	0	0
<i>Zygadenus elegans</i>	Liliaceae	0	0	1	0	0	0	0
<i>Linum lewisii</i>	Linaceae	0	1	0	0	0	0	0
<i>Epilobium angustifolium</i>	Onagraceae	0	1	0	0	0	0	0

Appendix 1

Virginia Basin Plant Assemblage	Symmetry	Size		Flower Orientation		
Species	Zygomorphic	Medium/ Small	Mechanically Strong	Pendant	Upright	Horizontal
<i>Ligusticum porteri</i>	0	1	0	0	0	1
<i>Pseudocymopterus montanus</i>	0	1	0	0	1	0
<i>Achillia lanulosa</i>	0	1	0	0	0	1
<i>Agoseris aurantiaca</i>	0	1	0	0	0	1
<i>Agoseris glauca</i>	0	1	0	0	0	1
<i>Antennaria rosea</i>	0	1	0	0	0	1
<i>Arnica cordifolia</i>	0	1	0	0	0	1
<i>Arnica parryi</i>	0	1	0	0	0	1
<i>Arnica rydbergii</i>	0	1	0	0	0	1
<i>Cirsium scopulorum</i>	0	1	0	0	0	1
<i>Erigeron elatior</i>	0	1	0	0	0	1
<i>Erigeron peregrinus</i>	1	1	0	0	1	0
<i>Erigeron speciosus</i>	0	1	0	0	0	1
<i>Helenium hoopesii</i>	0	1	1	0	0	1
<i>Helianthella quinquenervis</i>	0	0	0	0	1	0
<i>Heterotheca villosa</i>	0	1	0	0	1	0
<i>Senecio bigelovii</i>	0	1	0	0	0	1
<i>Senecio crassulus</i>	0	1	0	1	0	0
<i>Solidago spathulata</i>	0	1	0	0	0	1
<i>Mertensia ciliata</i>	0	0	0	1	0	0
<i>Arabis drummondii</i>	0	1	0	0	1	0
<i>Descurainia pinnata</i>	1	0	0	0	1	0
<i>Lonicera involucrata</i>	0	1	0	1	0	0
<i>Arenana congesta</i>	0	1	0	0	0	1
<i>Sedum integrifolium</i>	0	1	1	0	0	1
<i>Sedum stenopetalum</i>	0	1	1	0	0	1
<i>Astragalus alpinus</i>	0	1	0	0	1	0
<i>Lathyrus leucanthus</i>	1	1	0	0	1	0
<i>Vicia americana</i>	0	1	0	0	1	0
<i>Gentiana heterosepala</i>	0	1	0	0	0	1
<i>Gentianella amarella</i>	0	1	0	0	1	0
<i>Gentianella parryi</i>	0	1	0	1	0	1
<i>Gentianopsis detonsa</i>	0	1	0	0	0	1
<i>Geranium richardsonii</i>	0	0	0	0	0	1
<i>Hydrophyllum fendleri</i>	0	1	0	0	0	1
<i>Zygadenus elegans</i>	0	1	0	0	1	0
<i>Linum lewisii</i>	0	1	0	0	0	1
<i>Epilobium angustifolium</i>	0	1	0	0	0	1

Appendix 1

Virginia Basin Plant Assemblage	Anthers		Tube Morphology				Time of Opening
Species	Stiff	Exposed	Narrow	Wide	Short	Long	Day
<i>Ligusticum porteri</i>	0	1	0	0	0	0	1
<i>Pseudocymopterus montanus</i>	0	1	0	0	0	0	1
<i>Achillia lanulosa</i>	0	1	1	0	1	0	1
<i>Agoseris aurantiaca</i>	0	1	1	0	1	0	1
<i>Agoseris glauca</i>	0	1	1	0	1	0	1
<i>Antennaria rosea</i>	0	1	1	0	1	0	1
<i>Arnica cordifolia</i>	0	1	1	0	1	0	1
<i>Arnica parryi</i>	0	1	1	0	1	0	1
<i>Arnica rydbergii</i>	0	1	1	0	1	0	1
<i>Cirsium scopulorum</i>	0	1	1	0	1	0	1
<i>Erigeron elatior</i>	0	1	1	0	1	0	1
<i>Erigeron peregrinus</i>	0	1	0	0	0	0	1
<i>Erigeron speciosus</i>	0	1	1	0	1	0	1
<i>Helenium hoopesii</i>	0	0	0	1	1	0	1
<i>Helianthella quinquenervis</i>	0	1	0	0	0	0	1
<i>Heterotheca villosa</i>	0	1	1	0	1	0	1
<i>Senecio bigelovii</i>	0	1	1	0	1	0	1
<i>Senecio crassulus</i>	0	1	1	0	1	0	1
<i>Solidago spathulata</i>	0	1	1	0	1	0	1
<i>Mertensia ciliata</i>	0	0	1	0	1	0	1
<i>Arabis drummondii</i>	0	1	1	0	1	0	1
<i>Descurainia pinnata</i>	0	0	1	0	0	1	1
<i>Lonicera involucrata</i>	0	0	0	1	0	1	1
<i>Arenana congesta</i>	0	1	1	0	1	0	1
<i>Sedum integrifolium</i>	0	1	0	0	0	0	0
<i>Sedum stenopetalum</i>	0	1	0	0	0	0	1
<i>Astragalus alpinus</i>	0	0	0	0	0	0	1
<i>Lathyrus leucanthus</i>	0	0	0	0	0	0	1
<i>Vicia americana</i>	0	0	0	0	0	0	1
<i>Gentiana heterosepala</i>	0	1	1	0	1	0	1
<i>Gentianella amarella</i>	0	1	0	0	0	0	1
<i>Gentianella parryi</i>	0	0	0	1	1	0	1
<i>Gentianopsis detonsa</i>	0	0	0	1	0	1	1
<i>Geranium richardsonii</i>	0	0	0	1	0	1	1
<i>Hydrophyllum fendleri</i>	0	1	0	0	0	0	1
<i>Zygadenus elegans</i>	0	1	0	0	0	0	1
<i>Linum lewisii</i>	0	1	0	0	0	0	1
<i>Epilobium angustifolium</i>	0	1	0	0	0	0	1

Appendix 1

Virginia Basin Plant Assemblage	Odor Strength		Scent Type					
Species	Strong	None	Sweet	Fruity	Fresh	Musky	Sour	Decaying
<i>Ligusticum porteri</i>	0	0	1	0	1	0	0	0
<i>Pseudocymopterus montanus</i>	0	1	0	0	0	0	0	0
<i>Achillia lanulosa</i>	0	1	0	0	0	0	0	0
<i>Agoseris aurantiaca</i>	0	1	0	0	1	0	0	0
<i>Agoseris glauca</i>	0	0	1	0	0	0	0	0
<i>Antennaria rosea</i>	0	0	0	0	0	0	1	0
<i>Arnica cordifolia</i>	0	0	1	0	0	0	0	0
<i>Arnica parryi</i>	0	0	1	0	0	0	0	0
<i>Arnica rydbergii</i>	0	0	1	0	1	0	0	0
<i>Cirsium scopulorum</i>	0	1	0	0	0	0	0	0
<i>Erigeron elatior</i>	0	1	0	0	0	0	0	0
<i>Erigeron peregrinus</i>	0	0	1	0	0	0	0	0
<i>Erigeron speciosus</i>	0	1	0	0	0	0	0	0
<i>Helenium hoopesii</i>	0	1	0	0	0	0	0	0
<i>Helianthella quinquenervis</i>	0	1	0	0	0	0	0	0
<i>Heterotheca villosa</i>	0	1	0	0	0	0	0	0
<i>Senecio bigelovii</i>	0	0	0	0	0	1	0	0
<i>Senecio crassulus</i>	1	0	0	0	0	1	0	0
<i>Solidago spathulata</i>	0	0	1	0	0	0	0	0
<i>Mertensia ciliata</i>	0	0	1	0	0	0	0	0
<i>Arabis drummondii</i>	0	1	0	0	0	0	0	0
<i>Descurainia pinnata</i>	0	1	0	0	0	0	0	0
<i>Lonicera involucrata</i>	0	1	0	0	0	0	0	0
<i>Arenana congesta</i>	0	0	0	0	0	0	1	0
<i>Sedum integrifolium</i>	0	1	0	0	0	0	0	0
<i>Sedum stenopetalum</i>	0	1	0	0	0	0	0	0
<i>Astragalus alpinus</i>	0	1	0	0	0	0	0	0
<i>Lathyrus leucanthus</i>	0	1	0	0	0	0	0	0
<i>Vicia americana</i>	0	1	0	0	0	0	0	0
<i>Gentiana heterosepala</i>	0	1	0	0	0	0	0	0
<i>Gentianella amarella</i>	0	1	0	0	0	0	0	0
<i>Gentianella parryi</i>	0	1	0	0	0	0	0	0
<i>Gentianopsis detonsa</i>	0	1	0	0	0	0	0	0
<i>Geranium richardsonii</i>	1	0	1	0	0	0	0	0
<i>Hydrophyllum fendleri</i>	0	1	0	0	0	0	0	0
<i>Zygadenus elegans</i>	0	1	0	0	0	0	0	0
<i>Linum lewisii</i>	0	1	0	0	0	0	0	0
<i>Epilobium angustifolium</i>	0	0	1	0	0	0	0	0

Appendix 1

Virginia Basin Plant Assemblage	Color Brightness	Color						
Species	Vivid	Brown	White	Red	Green	Yellow	Blue	Purple
<i>Ligusticum porteri</i>	0	0	1	0	0	0	0	0
<i>Pseudocymopterus montanus</i>	1	0	0	0	0	1	0	0
<i>Achillia lanulosa</i>	0	0	1	0	0	0	0	0
<i>Agoseris aurantiaca</i>	0	0	0	0	0	0	0	0
<i>Agoseris glauca</i>	0	0	0	0	0	1	0	0
<i>Antennaria rosea</i>	0	0	1	1	0	1	0	0
<i>Arnica cordifolia</i>	1	0	0	0	0	1	0	0
<i>Arnica parryi</i>	0	0	0	0	0	1	0	0
<i>Arnica rydbergii</i>	1	0	0	0	0	1	0	0
<i>Cirsium scopulorum</i>	1	0	0	0	0	1	0	0
<i>Erigeron elatior</i>	1	0	0	0	0	1	0	0
<i>Erigeron peregrinus</i>	1	0	0	0	0	0	0	1
<i>Erigeron speciosus</i>	1	0	0	0	0	1	0	1
<i>Helenium hoopesii</i>	0	0	0	0	0	0	0	1
<i>Helianthella quinquenervis</i>	1	0	1	0	0	0	0	0
<i>Heterotheca villosa</i>	1	0	0	0	0	1	0	0
<i>Senecio bigelovii</i>	0	0	1	0	0	1	0	0
<i>Senecio crassulus</i>	0	1	0	0	0	1	0	0
<i>Solidago spatulata</i>	0	0	0	0	0	1	0	0
<i>Mertensia ciliata</i>	1	0	0	0	0	0	0	1
<i>Arabis drummondii</i>	1	0	1	0	0	0	0	0
<i>Descurainia pinnata</i>	1	0	0	0	0	0	1	1
<i>Lonicera involucrata</i>	0	0	0	1	0	1	0	0
<i>Arenaria congesta</i>	0	0	1	0	0	0	0	0
<i>Sedum integrifolium</i>	0	1	0	1	0	0	0	0
<i>Sedum stenopetalum</i>	1	0	0	0	0	1	0	0
<i>Astragalus alpinus</i>	0	0	0	0	0	1	0	1
<i>Lathyrus leucanthus</i>	0	0	1	0	0	0	0	0
<i>Vicia americana</i>	1	0	0	0	0	0	0	1
<i>Gentiana heterosepala</i>	1	0	0	0	0	1	0	1
<i>Gentianella amarella</i>	1	0	1	0	0	0	0	0
<i>Gentianella parryi</i>	0	0	0	0	0	0	0	1
<i>Gentianopsis detonsa</i>	1	0	0	0	1	0	1	0
<i>Geranium richardsonii</i>	1	0	0	0	0	0	1	0
<i>Hydrophyllum fendleri</i>	0	0	1	0	0	0	0	1
<i>Zygadenus elegans</i>	0	0	1	0	0	1	0	0
<i>Linum lewisii</i>	1	0	0	0	0	1	1	0
<i>Epilobium angustifolium</i>	0	0	0	0	0	1	0	0

Appendix 1

Virginia Basin Plant Assemblage	Nectar		Nectar Volume	
Species	Guides	Present	Abundant	Moderate
<i>Ligusticum porteri</i>	0	1	0	0
<i>Pseudocymopterus montanus</i>	0	1	0	0
<i>Achillia lanulosa</i>	0	1	1	0
<i>Agoseris aurantiaca</i>	1	1	0	0
<i>Agoseris glauca</i>	0	1	0	0
<i>Antennaria rosea</i>	0	1	0	0
<i>Arnica cordifolia</i>	0	1	0	0
<i>Arnica parryi</i>	0	1	0	0
<i>Arnica rydbergii</i>	0	1	0	0
<i>Cirsium scopulorum</i>	0	1	0	0
<i>Erigeron elatior</i>	0	1	0	0
<i>Erigeron peregrinus</i>	0	1	0	1
<i>Erigeron speciosus</i>	0	1	0	0
<i>Helenium hoopesii</i>	0	0	0	0
<i>Helianthella quinquenervis</i>	1	1	0	0
<i>Heterotheca villosa</i>	0	1	0	0
<i>Senecio bigelovii</i>	0	1	0	0
<i>Senecio crassulus</i>	0	1	0	0
<i>Solidago spathulata</i>	0	1	0	0
<i>Mertensia ciliata</i>	0	1	0	1
<i>Arabis drummondii</i>	0	1	0	0
<i>Descurainia pinnata</i>	1	1	0	1
<i>Lonicera involucrata</i>	0	1	1	0
<i>Arenaria congesta</i>	0	0	0	0
<i>Sedum integrifolium</i>	0	1	0	0
<i>Sedum stenopetalum</i>	0	1	0	0
<i>Astragalus alpinus</i>	0	0	0	0
<i>Lathyrus leucanthus</i>	1	1	0	1
<i>Vicia americana</i>	0	1	0	1
<i>Gentiana heterosepala</i>	0	1	0	0
<i>Gentianella amarella</i>	0	1	0	0
<i>Gentianella parryi</i>	0	0	0	0
<i>Gentianopsis detonsa</i>	1	1	0	1
<i>Geranium richardsonii</i>	1	1	1	0
<i>Hydrophyllum fendleri</i>	1	1	0	0
<i>Zygadenus elegans</i>	1	1	0	0
<i>Linum lewisii</i>	1	1	0	0
<i>Epilobium angustifolium</i>	0	1	0	0

Appendix 1

Virginia Basin Plant Assemblage		Flower Shape						
Species	Family	Trap	Open	Bell	Brush	Gullet	Flag	Tube
<i>Polemonium pulcherrimum</i>	Polimoniaceae	0	1	0	0	0	0	0
<i>Polygonum bistortoides</i>	Polygoniaceae	0	0	1	0	0	0	0
<i>Androsace septentrionalis</i>	Primulaceae	0	0	0	0	0	0	1
<i>Aquilegia caerulea</i>	Ranunculaceae	0	0	0	0	0	0	1
<i>Delphinium barbeyi</i>	Ranunculaceae	0	0	0	0	0	0	1
<i>Fragaria virginiana</i>	Rosaceae	0	0	0	0	0	0	1
<i>Potentilla fruticosa</i>	Rosaceae	0	1	0	0	0	0	0
<i>Potentilla sp.</i>	Rosaceae	0	1	0	0	0	0	0
<i>Castilleja miniata</i>	Scrophulariaceae	0	0	0	0	1	0	0
<i>Castilleja occidentalis</i>	Scrophulariaceae	0	0	0	0	1	0	0
<i>Castilleja rhexifolia</i>	Scrophulariaceae	0	0	0	0	0	0	1
<i>Pedicularis bracteosa</i>	Scrophulariaceae	0	0	0	0	0	0	1
<i>Pedicularis groenlandica</i>	Scrophulariaceae	0	0	0	0	0	0	1
<i>Pedicularis racemosa</i>	Scrophulariaceae	0	0	0	0	0	0	1
<i>Penstemon whippleanus</i>	Scrophulariaceae	0	0	0	0	0	0	1
<i>Valeriana edulis</i>	Valerianaceae	0	0	0	0	0	0	1
<i>Valeriana occidentalis</i>	Valerianaceae	0	0	0	0	0	0	1

Appendix 1

Virginia Basin Plant Assemblage	Symmetry	Size		Flower Orientation		
Species	Zygomorphic	Medium/ Small	Mechanically Strong	Pendant	Upright	Horizontal
<i>Polemonium pulcherrimum</i>	0	1	0	0	0	1
<i>Polygonum bistortoides</i>	0	1	1	0	0	1
<i>Androsace septentrionalis</i>	0	1	0	0	0	1
<i>Aquilegia caerulea</i>	0	0	0	0	1	0
<i>Delphinium barbeyi</i>	0	1	0	0	0	1
<i>Fragaria virginiana</i>	0	1	0	0	0	1
<i>Potentilla fruticosa</i>	0	1	0	0	0	1
<i>Potentilla sp.</i>	0	1	0	0	1	0
<i>Castilleja miniata</i>	0	1	0	0	1	0
<i>Castilleja occidentalis</i>	0	0	0	0	1	0
<i>Castilleja rhexifolia</i>	1	1	0	0	0	1
<i>Pedicularis bracteosa</i>	1	1	0	0	1	0
<i>Pedicularis groenlandica</i>	1	1	0	0	1	0
<i>Pedicularis racemosa</i>	1	1	0	0	1	0
<i>Penstemon whippleanus</i>	1	0	0	0	1	0
<i>Valeriana edulis</i>	0	1	0	0	0	1
<i>Valeriana occidentalis</i>	0	1	0	0	0	1

Appendix 1

Virginia Basin Plant Assemblage	Anthers		Tube Morphology				Time of Opening
Species	Stiff	Exposed	Narrow	Wide	Short	Long	Day
<i>Polemonium pulcherrimum</i>	0	1	0	0	0	0	1
<i>Polygonum bistortoides</i>	0	1	1	0	1	0	1
<i>Androsace septentrionalis</i>	0	0	1	0	1	0	1
<i>Aquilegia caerulea</i>	0	1	1	0	0	1	1
<i>Delphinium barbeyi</i>	0	1	1	0	1	0	1
<i>Fragaria virginiana</i>	0	0	1	0	1	0	1
<i>Potentilla fruticosa</i>	0	1	0	0	0	0	1
<i>Potentilla sp.</i>	0	1	0	0	0	0	1
<i>Castilleja miniata</i>	0	1	1	0	0	1	1
<i>Castilleja occidentalis</i>	0	0	1	0	0	1	1
<i>Castilleja rhexifolia</i>	0	0	1	0	0	1	1
<i>Pedicularis bracteosa</i>	0	1	1	0	0	1	1
<i>Pedicularis groenlandica</i>	0	0	1	0	1	0	1
<i>Pedicularis racemosa</i>	0	0	1	0	0	1	0
<i>Penstemon whippleanus</i>	0	0	0	1	0	1	1
<i>Valeriana edulis</i>	0	1	1	0	1	0	1
<i>Valeriana occidentalis</i>	0	1	1	0	1	0	1

Appendix 1

Virginia Basin Plant Assemblage	Odor Strength		Scent Type					
Species	Strong	None	Sweet	Fruity	Fresh	Musky	Sour	Decaying
<i>Polemonium pulcherrimum</i>	1	0	0	0	0	0	1	0
<i>Polygonum bistortoides</i>	0	0	1	0	0	0	0	0
<i>Androsace septentrionalis</i>	0	1	0	0	0	0	0	0
<i>Aquilegia caerulea</i>	0	0	1	0	0	0	0	0
<i>Delphinium barbeyi</i>	0	0	1	0	0	1	0	0
<i>Fragaria virginiana</i>	0	1	0	0	0	0	1	0
<i>Potentilla fruticosa</i>	0	1	0	0	0	0	0	0
<i>Potentilla sp.</i>	0	1	0	0	0	0	0	0
<i>Castilleja miniata</i>	0	1	0	0	0	0	0	0
<i>Castilleja occidentalis</i>	0	1	0	0	0	0	0	0
<i>Castilleja rhexifolia</i>	0	1	0	0	0	0	0	0
<i>Pedicularis bracteosa</i>	0	1	0	0	0	0	0	0
<i>Pedicularis groenlandica</i>	0	1	0	0	0	0	0	0
<i>Pedicularis racemosa</i>	0	1	0	0	0	0	0	0
<i>Penstemon whippleanus</i>	0	1	0	0	0	0	0	0
<i>Valeriana edulis</i>	0	0	1	0	0	0	0	0
<i>Valeriana occidentalis</i>	0	0	1	0	1	0	0	0

Appendix 1

Virginia Basin Plant Assemblage	Color Brightness	Color						
Species	Vivid	Brown	White	Red	Green	Yellow	Blue	Purple
<i>Polemonium pulcherrimum</i>	0	0	0	0	0	0	1	0
<i>Polygonum bistortoides</i>	0	0	1	0	0	0	0	0
<i>Androsace septentrionalis</i>	0	0	1	0	0	1	0	0
<i>Aquilegia caerulea</i>	1	0	1	0	0	0	1	0
<i>Delphinium barbeyi</i>	0	0	0	0	0	0	0	1
<i>Fragaria virginiana</i>	0	0	1	0	0	1	0	0
<i>Potentilla fruticosa</i>	1	0	0	0	0	1	0	0
<i>Potentilla sp.</i>	1	0	0	0	0	1	0	0
<i>Castilleja miniata</i>	1	0	0	1	0	0	0	0
<i>Castilleja occidentalis</i>	0	0	0	0	1	0	0	0
<i>Castilleja rhexifolia</i>	0	0	0	1	0	0	0	0
<i>Pedicularis bracteosa</i>	0	0	0	0	0	1	0	0
<i>Pedicularis groenlandica</i>	1	0	0	1	0	0	0	0
<i>Pedicularis racemosa</i>	0	0	1	0	0	1	0	0
<i>Penstemon whippleanus</i>	0	0	0	0	0	0	0	1
<i>Valeriana edulis</i>	0	0	1	0	0	0	0	1
<i>Valeriana occidentalis</i>	1	0	1	0	0	0	0	0

Appendix 1

Virginia Basin Plant Assemblage	Nectar		Nectar Volume	
Species	Guides	Present	Abundant	Moderate
<i>Polemonium pulcherrimum</i>	1	1	0	0
<i>Polygonum bistortoides</i>	0	1	0	0
<i>Androsace septentrionalis</i>	1	1	0	0
<i>Aquilegia caerulea</i>	0	1	0	1
<i>Delphinium barbeyi</i>	0	1	0	1
<i>Fragaria virginiana</i>	0	1	0	0
<i>Potentilla fruticosa</i>	0	1	0	0
<i>Potentilla sp.</i>	1	1	0	0
<i>Castilleja miniata</i>	0	1	0	1
<i>Castilleja occidentalis</i>	0	1	0	1
<i>Castilleja rhexifolia</i>	0	1	1	0
<i>Pedicularis bracteosa</i>	0	1	0	1
<i>Pedicularis groenlandica</i>	0	1	0	0
<i>Pedicularis racemosa</i>	0	1	0	1
<i>Penstemon whippleanus</i>	1	1	1	0
<i>Valeriana edulis</i>	1	1	0	0
<i>Valeriana occidentalis</i>	0	1	0	0

Appendix 2

Idealized floral trait combinations (686) for the 11 classic pollination syndromes as described in the literature (e.g. Faegri and van der Pijl 1966; see Chapter 2 Methods). Multiple 40-trait combinations represent each syndrome.

Idealized Trait Combinations		Flower Shape							Size	
Number	Pollination Syndrome	Trap	Open	Bell	Brush	Gullet	Flag	Tube	Medium/ Small	Mechanically Strong
1	Bat	0	1	0	0	0	0	0	0	1
2	Bat	0	1	0	0	0	0	0	0	1
3	Bat	0	1	0	0	0	0	0	0	1
4	Bat	0	1	0	0	0	0	0	0	1
5	Bat	0	1	0	0	0	0	0	0	1
6	Bat	0	1	0	0	0	0	0	0	1
7	Bat	0	1	0	0	0	0	0	0	1
8	Bat	0	1	0	0	0	0	0	0	1
9	Bat	0	1	0	0	0	0	0	0	1
10	Bat	0	0	1	0	0	0	0	0	1
11	Bat	0	0	1	0	0	0	0	0	1
12	Bat	0	0	1	0	0	0	0	0	1
13	Bat	0	0	1	0	0	0	0	0	1
14	Bat	0	0	1	0	0	0	0	0	1
15	Bat	0	0	1	0	0	0	0	0	1
16	Bat	0	0	1	0	0	0	0	0	1
17	Bat	0	0	1	0	0	0	0	0	1
18	Bat	0	0	1	0	0	0	0	0	1
19	Bat	0	0	0	1	0	0	0	0	1
20	Bat	0	0	0	1	0	0	0	0	1
21	Bat	0	0	0	1	0	0	0	0	1
22	Bat	0	0	0	1	0	0	0	0	1
23	Bat	0	0	0	1	0	0	0	0	1
24	Bat	0	0	0	1	0	0	0	0	1
25	Bat	0	0	0	1	0	0	0	0	1
26	Bat	0	0	0	1	0	0	0	0	1
27	Bat	0	0	0	1	0	0	0	0	1
28	Bat	0	0	0	0	1	0	0	0	1
29	Bat	0	0	0	0	1	0	0	0	1
30	Bat	0	0	0	0	1	0	0	0	1
31	Bat	0	0	0	0	1	0	0	0	1
32	Bat	0	0	0	0	1	0	0	0	1
33	Bat	0	0	0	0	1	0	0	0	1
34	Bat	0	0	0	0	1	0	0	0	1
35	Bat	0	0	0	0	1	0	0	0	1
36	Bat	0	0	0	0	1	0	0	0	1

Appendix 2

Idealized Trait Combinations		Symmetry	Anthers		Flower Orientation		
Number	Pollination Syndrome	Zygomorphic	Stiff	Exposed	Pendant	Upright	Horizontal
1	Bat	0	0	0	1	0	0
2	Bat	0	0	0	1	0	0
3	Bat	0	0	0	1	0	0
4	Bat	0	0	0	0	1	0
5	Bat	0	0	0	0	1	0
6	Bat	0	0	0	0	1	0
7	Bat	0	0	0	0	0	1
8	Bat	0	0	0	0	0	1
9	Bat	0	0	0	0	0	1
10	Bat	0	0	0	1	0	0
11	Bat	0	0	0	1	0	0
12	Bat	0	0	0	1	0	0
13	Bat	0	0	0	0	1	0
14	Bat	0	0	0	0	1	0
15	Bat	0	0	0	0	1	0
16	Bat	0	0	0	0	0	1
17	Bat	0	0	0	0	0	1
18	Bat	0	0	0	0	0	1
19	Bat	0	0	0	1	0	0
20	Bat	0	0	0	1	0	0
21	Bat	0	0	0	1	0	0
22	Bat	0	0	0	0	1	0
23	Bat	0	0	0	0	1	0
24	Bat	0	0	0	0	1	0
25	Bat	0	0	0	0	0	1
26	Bat	0	0	0	0	0	1
27	Bat	0	0	0	0	0	1
28	Bat	0	0	0	1	0	0
29	Bat	0	0	0	1	0	0
30	Bat	0	0	0	1	0	0
31	Bat	0	0	0	0	1	0
32	Bat	0	0	0	0	1	0
33	Bat	0	0	0	0	1	0
34	Bat	0	0	0	0	0	1
35	Bat	0	0	0	0	0	1
36	Bat	0	0	0	0	0	1

Appendix 2

Idealized Trait Combinations		Tube Morphology				Time of Opening	Nectar		Nectar Volume	
Number	Pollination Syndrome	Narrow	Wide	Short	Long	Day	Guides	Present	Abundant	Moderate
1	Bat	0	0	0	0	0	0	1	1	0
2	Bat	0	0	0	0	0	0	1	1	0
3	Bat	0	0	0	0	0	0	1	1	0
4	Bat	0	0	0	0	0	0	1	1	0
5	Bat	0	0	0	0	0	0	1	1	0
6	Bat	0	0	0	0	0	0	1	1	0
7	Bat	0	0	0	0	0	0	1	1	0
8	Bat	0	0	0	0	0	0	1	1	0
9	Bat	0	0	0	0	0	0	1	1	0
10	Bat	0	0	0	0	0	0	1	1	0
11	Bat	0	0	0	0	0	0	1	1	0
12	Bat	0	0	0	0	0	0	1	1	0
13	Bat	0	0	0	0	0	0	1	1	0
14	Bat	0	0	0	0	0	0	1	1	0
15	Bat	0	0	0	0	0	0	1	1	0
16	Bat	0	0	0	0	0	0	1	1	0
17	Bat	0	0	0	0	0	0	1	1	0
18	Bat	0	0	0	0	0	0	1	1	0
19	Bat	0	0	0	0	0	0	1	1	0
20	Bat	0	0	0	0	0	0	1	1	0
21	Bat	0	0	0	0	0	0	1	1	0
22	Bat	0	0	0	0	0	0	1	1	0
23	Bat	0	0	0	0	0	0	1	1	0
24	Bat	0	0	0	0	0	0	1	1	0
25	Bat	0	0	0	0	0	0	1	1	0
26	Bat	0	0	0	0	0	0	1	1	0
27	Bat	0	0	0	0	0	0	1	1	0
28	Bat	0	0	0	0	0	0	1	1	0
29	Bat	0	0	0	0	0	0	1	1	0
30	Bat	0	0	0	0	0	0	1	1	0
31	Bat	0	0	0	0	0	0	1	1	0
32	Bat	0	0	0	0	0	0	1	1	0
33	Bat	0	0	0	0	0	0	1	1	0
34	Bat	0	0	0	0	0	0	1	1	0
35	Bat	0	0	0	0	0	0	1	1	0
36	Bat	0	0	0	0	0	0	1	1	0

Appendix 2

Idealized Trait Combinations		Odor Strength		Scent Type					
Number	Pollination Syndrome	Strong	None	Sweet	Fruity	Fresh	Musky	Sour	Decaying
1	Bat	1	0	0	1	0	0	0	0
2	Bat	1	0	0	0	0	1	0	0
3	Bat	1	0	0	0	0	0	1	0
4	Bat	1	0	0	1	0	0	0	0
5	Bat	1	0	0	0	0	1	0	0
6	Bat	1	0	0	0	0	0	1	0
7	Bat	1	0	0	1	0	0	0	0
8	Bat	1	0	0	0	0	1	0	0
9	Bat	1	0	0	0	0	0	1	0
10	Bat	1	0	0	1	0	0	0	0
11	Bat	1	0	0	0	0	1	0	0
12	Bat	1	0	0	0	0	0	1	0
13	Bat	1	0	0	1	0	0	0	0
14	Bat	1	0	0	0	0	1	0	0
15	Bat	1	0	0	0	0	0	1	0
16	Bat	1	0	0	1	0	0	0	0
17	Bat	1	0	0	0	0	1	0	0
18	Bat	1	0	0	0	0	0	1	0
19	Bat	1	0	0	1	0	0	0	0
20	Bat	1	0	0	0	0	1	0	0
21	Bat	1	0	0	0	0	0	1	0
22	Bat	1	0	0	1	0	0	0	0
23	Bat	1	0	0	0	0	1	0	0
24	Bat	1	0	0	0	0	0	1	0
25	Bat	1	0	0	1	0	0	0	0
26	Bat	1	0	0	0	0	1	0	0
27	Bat	1	0	0	0	0	0	1	0
28	Bat	1	0	0	1	0	0	0	0
29	Bat	1	0	0	0	0	1	0	0
30	Bat	1	0	0	0	0	0	1	0
31	Bat	1	0	0	1	0	0	0	0
32	Bat	1	0	0	0	0	1	0	0
33	Bat	1	0	0	0	0	0	1	0
34	Bat	1	0	0	1	0	0	0	0
35	Bat	1	0	0	0	0	1	0	0
36	Bat	1	0	0	0	0	0	1	0

Appendix 2

Idealized Trait Combinations		Color Brightness	Color						
Number	Pollination Syndrome	Vivid	Brown	White	Red	Green	Yellow	Blue	Purple
1	Bat	0	0	1	0	0	0	0	0
2	Bat	0	0	1	0	0	0	0	0
3	Bat	0	0	1	0	0	0	0	0
4	Bat	0	0	1	0	0	0	0	0
5	Bat	0	0	1	0	0	0	0	0
6	Bat	0	0	1	0	0	0	0	0
7	Bat	0	0	1	0	0	0	0	0
8	Bat	0	0	1	0	0	0	0	0
9	Bat	0	0	1	0	0	0	0	0
10	Bat	0	0	1	0	0	0	0	0
11	Bat	0	0	1	0	0	0	0	0
12	Bat	0	0	1	0	0	0	0	0
13	Bat	0	0	1	0	0	0	0	0
14	Bat	0	0	1	0	0	0	0	0
15	Bat	0	0	1	0	0	0	0	0
16	Bat	0	0	1	0	0	0	0	0
17	Bat	0	0	1	0	0	0	0	0
18	Bat	0	0	1	0	0	0	0	0
19	Bat	0	0	1	0	0	0	0	0
20	Bat	0	0	1	0	0	0	0	0
21	Bat	0	0	1	0	0	0	0	0
22	Bat	0	0	1	0	0	0	0	0
23	Bat	0	0	1	0	0	0	0	0
24	Bat	0	0	1	0	0	0	0	0
25	Bat	0	0	1	0	0	0	0	0
26	Bat	0	0	1	0	0	0	0	0
27	Bat	0	0	1	0	0	0	0	0
28	Bat	0	0	1	0	0	0	0	0
29	Bat	0	0	1	0	0	0	0	0
30	Bat	0	0	1	0	0	0	0	0
31	Bat	0	0	1	0	0	0	0	0
32	Bat	0	0	1	0	0	0	0	0
33	Bat	0	0	1	0	0	0	0	0
34	Bat	0	0	1	0	0	0	0	0
35	Bat	0	0	1	0	0	0	0	0
36	Bat	0	0	1	0	0	0	0	0

Appendix 2

Idealized Trait Combinations		Flower Shape							Size	
Number	Pollination Syndrome	Trap	Open	Bell	Brush	Gullet	Flag	Tube	Medium/ Small	Mechanically Strong
37	Butterfly	0	0	0	1	0	0	0	1	0
38	Butterfly	0	0	0	1	0	0	0	1	0
39	Butterfly	0	0	0	1	0	0	0	1	0
40	Butterfly	0	0	0	1	0	0	0	1	0
41	Butterfly	0	0	0	1	0	0	0	1	0
42	Butterfly	0	0	0	1	0	0	0	1	0
43	Butterfly	0	0	0	0	1	0	0	1	0
44	Butterfly	0	0	0	0	1	0	0	1	0
45	Butterfly	0	0	0	0	1	0	0	1	0
46	Butterfly	0	0	0	0	1	0	0	1	0
47	Butterfly	0	0	0	0	1	0	0	1	0
48	Butterfly	0	0	0	0	1	0	0	1	0
49	Butterfly	0	0	0	0	0	1	0	1	0
50	Butterfly	0	0	0	0	0	1	0	1	0
51	Butterfly	0	0	0	0	0	1	0	1	0
52	Butterfly	0	0	0	0	0	1	0	1	0
53	Butterfly	0	0	0	0	0	1	0	1	0
54	Butterfly	0	0	0	0	0	1	0	1	0
55	Butterfly	0	0	0	0	0	0	1	1	0
56	Butterfly	0	0	0	0	0	0	1	1	0
57	Butterfly	0	0	0	0	0	0	1	1	0
58	Butterfly	0	0	0	0	0	0	1	1	0
59	Butterfly	0	0	0	0	0	0	1	1	0
60	Butterfly	0	0	0	0	0	0	1	1	0
61	Beetle	1	0	0	0	0	0	0	0	1
62	Beetle	1	0	0	0	0	0	0	0	1
63	Beetle	1	0	0	0	0	0	0	0	1
64	Beetle	1	0	0	0	0	0	0	0	1
65	Beetle	1	0	0	0	0	0	0	0	1
66	Beetle	1	0	0	0	0	0	0	0	1
67	Beetle	1	0	0	0	0	0	0	0	1
68	Beetle	1	0	0	0	0	0	0	0	1
69	Beetle	1	0	0	0	0	0	0	0	1
70	Beetle	1	0	0	0	0	0	0	0	1
71	Beetle	1	0	0	0	0	0	0	0	1
72	Beetle	1	0	0	0	0	0	0	0	1
73	Beetle	1	0	0	0	0	0	0	0	1
74	Beetle	1	0	0	0	0	0	0	0	1
75	Beetle	1	0	0	0	0	0	0	0	1

Appendix 2

Idealized Trait Combinations		Symmetry	Anthers		Flower Orientation		
Number	Pollination Syndrome	Zygomorphic	Stiff	Exposed	Pendant	Upright	Horizontal
37	Butterfly	0	0	0	0	1	0
38	Butterfly	0	0	0	0	1	0
39	Butterfly	0	0	0	0	1	0
40	Butterfly	0	0	0	0	1	0
41	Butterfly	0	0	0	0	1	0
42	Butterfly	0	0	0	0	1	0
43	Butterfly	0	0	0	0	1	0
44	Butterfly	0	0	0	0	1	0
45	Butterfly	0	0	0	0	1	0
46	Butterfly	0	0	0	0	1	0
47	Butterfly	0	0	0	0	1	0
48	Butterfly	0	0	0	0	1	0
49	Butterfly	0	0	0	0	1	0
50	Butterfly	0	0	0	0	1	0
51	Butterfly	0	0	0	0	1	0
52	Butterfly	0	0	0	0	1	0
53	Butterfly	0	0	0	0	1	0
54	Butterfly	0	0	0	0	1	0
55	Butterfly	0	0	0	0	1	0
56	Butterfly	0	0	0	0	1	0
57	Butterfly	0	0	0	0	1	0
58	Butterfly	0	0	0	0	1	0
59	Butterfly	0	0	0	0	1	0
60	Butterfly	0	0	0	0	1	0
61	Beetle	0	0	1	0	1	0
62	Beetle	0	0	1	0	1	0
63	Beetle	0	0	1	0	1	0
64	Beetle	0	0	1	0	1	0
65	Beetle	0	0	1	0	1	0
66	Beetle	0	0	1	0	1	0
67	Beetle	0	0	1	0	1	0
68	Beetle	0	0	1	0	1	0
69	Beetle	0	0	1	0	1	0
70	Beetle	0	0	1	0	1	0
71	Beetle	0	0	1	0	1	0
72	Beetle	0	0	1	0	1	0
73	Beetle	0	0	1	0	0	1
74	Beetle	0	0	1	0	0	1
75	Beetle	0	0	1	0	0	1

Appendix 2

Idealized Trait Combinations		Tube Morphology				Time of Opening	Nectar		Nectar Volume	
Number	Pollination Syndrome	Narrow	Wide	Short	Long	Day	Guides	Present	Abundant	Moderate
37	Butterfly	1	0	0	1	1	1	1	0	1
38	Butterfly	1	0	0	1	1	1	1	0	0
39	Butterfly	1	0	0	1	1	1	1	0	1
40	Butterfly	1	0	0	1	1	1	1	0	0
41	Butterfly	1	0	0	1	1	1	1	0	1
42	Butterfly	1	0	0	1	1	1	1	0	0
43	Butterfly	1	0	0	1	1	1	1	0	1
44	Butterfly	1	0	0	1	1	1	1	0	0
45	Butterfly	1	0	0	1	1	1	1	0	1
46	Butterfly	1	0	0	1	1	1	1	0	0
47	Butterfly	1	0	0	1	1	1	1	0	1
48	Butterfly	1	0	0	1	1	1	1	0	0
49	Butterfly	1	0	0	1	1	1	1	0	1
50	Butterfly	1	0	0	1	1	1	1	0	0
51	Butterfly	1	0	0	1	1	1	1	0	1
52	Butterfly	1	0	0	1	1	1	1	0	0
53	Butterfly	1	0	0	1	1	1	1	0	1
54	Butterfly	1	0	0	1	1	1	1	0	0
55	Butterfly	1	0	0	1	1	1	1	0	1
56	Butterfly	1	0	0	1	1	1	1	0	0
57	Butterfly	1	0	0	1	1	1	1	0	1
58	Butterfly	1	0	0	1	1	1	1	0	0
59	Butterfly	1	0	0	1	1	1	1	0	1
60	Butterfly	1	0	0	1	1	1	1	0	0
61	Beetle	0	0	0	0	1	0	1	0	0
62	Beetle	0	0	0	0	1	0	1	0	1
63	Beetle	0	0	0	0	1	0	1	0	1
64	Beetle	0	0	0	0	1	0	1	0	0
65	Beetle	0	0	0	0	1	0	1	0	1
66	Beetle	0	0	0	0	1	0	1	0	0
67	Beetle	0	0	0	0	0	0	1	0	1
68	Beetle	0	0	0	0	0	0	1	0	0
69	Beetle	0	0	0	0	0	0	1	0	1
70	Beetle	0	0	0	0	0	0	1	0	0
71	Beetle	0	0	0	0	0	0	1	0	1
72	Beetle	0	0	0	0	0	0	1	0	0
73	Beetle	0	0	0	0	1	0	1	0	1
74	Beetle	0	0	0	0	1	0	1	0	0
75	Beetle	0	0	0	0	1	0	1	0	1

Appendix 2

Idealized Trait Combinations		Odor Strength		Scent Type					
Number	Pollination Syndrome	Strong	None	Sweet	Fruity	Fresh	Musky	Sour	Decaying
37	Butterfly	0	0	0	0	1	0	0	0
38	Butterfly	0	0	0	0	1	0	0	0
39	Butterfly	0	0	0	0	1	0	0	0
40	Butterfly	0	0	0	0	1	0	0	0
41	Butterfly	0	0	0	0	1	0	0	0
42	Butterfly	0	0	0	0	1	0	0	0
43	Butterfly	0	0	0	0	1	0	0	0
44	Butterfly	0	0	0	0	1	0	0	0
45	Butterfly	0	0	0	0	1	0	0	0
46	Butterfly	0	0	0	0	1	0	0	0
47	Butterfly	0	0	0	0	1	0	0	0
48	Butterfly	0	0	0	0	1	0	0	0
49	Butterfly	0	0	0	0	1	0	0	0
50	Butterfly	0	0	0	0	1	0	0	0
51	Butterfly	0	0	0	0	1	0	0	0
52	Butterfly	0	0	0	0	1	0	0	0
53	Butterfly	0	0	0	0	1	0	0	0
54	Butterfly	0	0	0	0	1	0	0	0
55	Butterfly	0	0	0	0	1	0	0	0
56	Butterfly	0	0	0	0	1	0	0	0
57	Butterfly	0	0	0	0	1	0	0	0
58	Butterfly	0	0	0	0	1	0	0	0
59	Butterfly	0	0	0	0	1	0	0	0
60	Butterfly	0	0	0	0	1	0	0	0
61	Beetle	1	0	0	1	0	0	0	0
62	Beetle	1	0	0	1	0	0	0	0
63	Beetle	1	0	0	0	0	0	1	0
64	Beetle	1	0	0	0	0	0	1	0
65	Beetle	1	0	0	0	0	0	0	1
66	Beetle	1	0	0	0	0	0	0	1
67	Beetle	1	0	0	1	0	0	0	0
68	Beetle	1	0	0	1	0	0	0	0
69	Beetle	1	0	0	0	0	0	1	0
70	Beetle	1	0	0	0	0	0	1	0
71	Beetle	1	0	0	0	0	0	0	1
72	Beetle	1	0	0	0	0	0	0	1
73	Beetle	1	0	0	1	0	0	0	0
74	Beetle	1	0	0	1	0	0	0	0
75	Beetle	1	0	0	0	0	0	1	0

Appendix 2

Idealized Trait Combinations		Color Brightness	Color						
Number	Pollination Syndrome	Vivid	Brown	White	Red	Green	Yellow	Blue	Purple
37	Butterfly	1	0	0	1	0	0	0	0
38	Butterfly	1	0	0	1	0	0	0	0
39	Butterfly	1	0	0	0	0	1	0	0
40	Butterfly	1	0	0	0	0	1	0	0
41	Butterfly	1	0	0	0	0	0	1	0
42	Butterfly	1	0	0	0	0	0	1	0
43	Butterfly	1	0	0	1	0	0	0	0
44	Butterfly	1	0	0	1	0	0	0	0
45	Butterfly	1	0	0	0	0	1	0	0
46	Butterfly	1	0	0	0	0	1	0	0
47	Butterfly	1	0	0	0	0	0	1	0
48	Butterfly	1	0	0	0	0	0	1	0
49	Butterfly	1	0	0	1	0	0	0	0
50	Butterfly	1	0	0	1	0	0	0	0
51	Butterfly	1	0	0	0	0	1	0	0
52	Butterfly	1	0	0	0	0	1	0	0
53	Butterfly	1	0	0	0	0	0	1	0
54	Butterfly	1	0	0	0	0	0	1	0
55	Butterfly	1	0	0	1	0	0	0	0
56	Butterfly	1	0	0	1	0	0	0	0
57	Butterfly	1	0	0	0	0	1	0	0
58	Butterfly	1	0	0	0	0	1	0	0
59	Butterfly	1	0	0	0	0	0	1	0
60	Butterfly	1	0	0	0	0	0	1	0
61	Beetle	0	1	1	0	0	0	0	0
62	Beetle	0	1	1	0	0	0	0	0
63	Beetle	0	1	1	0	0	0	0	0
64	Beetle	0	1	1	0	0	0	0	0
65	Beetle	0	1	1	0	0	0	0	0
66	Beetle	0	1	1	0	0	0	0	0
67	Beetle	0	1	1	0	0	0	0	0
68	Beetle	0	1	1	0	0	0	0	0
69	Beetle	0	1	1	0	0	0	0	0
70	Beetle	0	1	1	0	0	0	0	0
71	Beetle	0	1	1	0	0	0	0	0
72	Beetle	0	1	1	0	0	0	0	0
73	Beetle	0	1	1	0	0	0	0	0
74	Beetle	0	1	1	0	0	0	0	0
75	Beetle	0	1	1	0	0	0	0	0

Appendix 2

Idealized Trait Combinations		Flower Shape							Size	
Number	Pollination Syndrome	Trap	Open	Bell	Brush	Gullet	Flag	Tube	Medium/ Small	Mechanically Strong
76	Beetle	1	0	0	0	0	0	0	0	1
77	Beetle	1	0	0	0	0	0	0	0	1
78	Beetle	1	0	0	0	0	0	0	0	1
79	Beetle	1	0	0	0	0	0	0	0	1
80	Beetle	1	0	0	0	0	0	0	0	1
81	Beetle	1	0	0	0	0	0	0	0	1
82	Beetle	1	0	0	0	0	0	0	0	1
83	Beetle	1	0	0	0	0	0	0	0	1
84	Beetle	1	0	0	0	0	0	0	0	1
85	Beetle	1	0	0	0	0	0	0	0	1
86	Beetle	1	0	0	0	0	0	0	0	1
87	Beetle	1	0	0	0	0	0	0	0	1
88	Beetle	1	0	0	0	0	0	0	0	1
89	Beetle	1	0	0	0	0	0	0	0	1
90	Beetle	1	0	0	0	0	0	0	0	1
91	Beetle	1	0	0	0	0	0	0	0	1
92	Beetle	1	0	0	0	0	0	0	0	1
93	Beetle	1	0	0	0	0	0	0	0	1
94	Beetle	1	0	0	0	0	0	0	0	1
95	Beetle	1	0	0	0	0	0	0	0	1
96	Beetle	1	0	0	0	0	0	0	0	1
97	Beetle	0	1	0	0	0	0	0	0	1
98	Beetle	0	1	0	0	0	0	0	0	1
99	Beetle	0	1	0	0	0	0	0	0	1
100	Beetle	0	1	0	0	0	0	0	0	1
101	Beetle	0	1	0	0	0	0	0	0	1
102	Beetle	0	1	0	0	0	0	0	0	1
103	Beetle	0	1	0	0	0	0	0	0	1
104	Beetle	0	1	0	0	0	0	0	0	1
105	Beetle	0	1	0	0	0	0	0	0	1
106	Beetle	0	1	0	0	0	0	0	0	1
107	Beetle	0	1	0	0	0	0	0	0	1
108	Beetle	0	1	0	0	0	0	0	0	1
109	Beetle	0	1	0	0	0	0	0	0	1
110	Beetle	0	1	0	0	0	0	0	0	1
111	Beetle	0	1	0	0	0	0	0	0	1
112	Beetle	0	1	0	0	0	0	0	0	1
113	Beetle	0	1	0	0	0	0	0	0	1
114	Beetle	0	1	0	0	0	0	0	0	1

Appendix 2

Idealized Trait Combinations		Symmetry	Anthers		Flower Orientation		
Number	Pollination Syndrome	Zygomorphic	Stiff	Exposed	Pendant	Upright	Horizontal
76	Beetle	0	0	1	0	0	1
77	Beetle	0	0	1	0	0	1
78	Beetle	0	0	1	0	0	1
79	Beetle	0	0	1	0	0	1
80	Beetle	0	0	1	0	0	1
81	Beetle	0	0	1	0	0	1
82	Beetle	0	0	1	0	0	1
83	Beetle	0	0	1	0	0	1
84	Beetle	0	0	1	0	0	1
85	Beetle	0	1	1	0	0	0
86	Beetle	0	1	1	0	0	0
87	Beetle	0	1	1	0	0	0
88	Beetle	0	1	1	0	0	0
89	Beetle	0	1	1	0	0	0
90	Beetle	0	1	1	0	0	0
91	Beetle	0	1	1	0	0	0
92	Beetle	0	1	1	0	0	0
93	Beetle	0	1	1	0	0	0
94	Beetle	0	1	1	0	0	0
95	Beetle	0	1	1	0	0	0
96	Beetle	0	1	1	0	0	0
97	Beetle	0	0	1	0	1	0
98	Beetle	0	0	1	0	1	0
99	Beetle	0	0	1	0	1	0
100	Beetle	0	0	1	0	1	0
101	Beetle	0	0	1	0	1	0
102	Beetle	0	0	1	0	1	0
103	Beetle	0	0	1	0	1	0
104	Beetle	0	0	1	0	1	0
105	Beetle	0	0	1	0	1	0
106	Beetle	0	0	1	0	1	0
107	Beetle	0	0	1	0	1	0
108	Beetle	0	0	1	0	1	0
109	Beetle	0	0	1	0	0	1
110	Beetle	0	0	1	0	0	1
111	Beetle	0	0	1	0	0	1
112	Beetle	0	0	1	0	0	1
113	Beetle	0	0	1	0	0	1
114	Beetle	0	0	1	0	0	1

Appendix 2

Idealized Trait Combinations		Tube Morphology				Time of Opening	Nectar		Nectar Volume	
Number	Pollination Syndrome	Narrow	Wide	Short	Long	Day	Guides	Present	Abundant	Moderate
76	Beetle	0	0	0	0	1	0	1	0	0
77	Beetle	0	0	0	0	1	0	1	0	1
78	Beetle	0	0	0	0	1	0	1	0	0
79	Beetle	0	0	0	0	0	0	1	0	1
80	Beetle	0	0	0	0	0	0	1	0	1
81	Beetle	0	0	0	0	0	0	1	0	1
82	Beetle	0	0	0	0	0	0	1	0	0
83	Beetle	0	0	0	0	0	0	1	0	1
84	Beetle	0	0	0	0	0	0	1	0	0
85	Beetle	0	0	0	0	1	0	1	0	1
86	Beetle	0	0	0	0	1	0	1	0	0
87	Beetle	0	0	0	0	1	0	1	0	1
88	Beetle	0	0	0	0	1	0	1	0	0
89	Beetle	0	0	0	0	1	0	1	0	1
90	Beetle	0	0	0	0	1	0	1	0	0
91	Beetle	0	0	0	0	0	0	1	0	1
92	Beetle	0	0	0	0	0	0	1	0	0
93	Beetle	0	0	0	0	0	0	1	0	1
94	Beetle	0	0	0	0	0	0	1	0	0
95	Beetle	0	0	0	0	0	0	1	0	1
96	Beetle	0	0	0	0	0	0	1	0	0
97	Beetle	0	0	0	0	1	0	1	0	1
98	Beetle	0	0	0	0	1	0	1	0	0
99	Beetle	0	0	0	0	1	0	1	0	1
100	Beetle	0	0	0	0	1	0	1	0	0
101	Beetle	0	0	0	0	1	0	1	0	1
102	Beetle	0	0	0	0	1	0	1	0	0
103	Beetle	0	0	0	0	0	0	1	0	1
104	Beetle	0	0	0	0	0	0	1	0	0
105	Beetle	0	0	0	0	0	0	1	0	1
106	Beetle	0	0	0	0	0	0	1	0	0
107	Beetle	0	0	0	0	0	0	1	0	1
108	Beetle	0	0	0	0	0	0	1	0	0
109	Beetle	0	0	0	0	1	0	1	0	1
110	Beetle	0	0	0	0	1	0	1	0	0
111	Beetle	0	0	0	0	1	0	1	0	1
112	Beetle	0	0	0	0	1	0	1	0	0
113	Beetle	0	0	0	0	1	0	1	0	1
114	Beetle	0	0	0	0	1	0	1	0	0

Appendix 2

Idealized Trait Combinations		Odor Strength		Scent Type					
Number	Pollination Syndrome	Strong	None	Sweet	Fruity	Fresh	Musky	Sour	Decaying
76	Beetle	1	0	0	0	0	0	1	0
77	Beetle	1	0	0	0	0	0	0	1
78	Beetle	1	0	0	0	0	0	0	1
79	Beetle	1	0	0	1	0	0	0	0
80	Beetle	1	0	0	1	0	0	0	0
81	Beetle	1	0	0	0	0	0	1	0
82	Beetle	1	0	0	0	0	0	1	0
83	Beetle	1	0	0	0	0	0	0	1
84	Beetle	1	0	0	0	0	0	0	1
85	Beetle	1	0	0	1	0	0	0	0
86	Beetle	1	0	0	1	0	0	0	0
87	Beetle	1	0	0	0	0	0	1	0
88	Beetle	1	0	0	0	0	0	1	0
89	Beetle	1	0	0	0	0	0	0	1
90	Beetle	1	0	0	0	0	0	0	1
91	Beetle	1	0	0	1	0	0	0	0
92	Beetle	1	0	0	1	0	0	0	0
93	Beetle	1	0	0	0	0	0	1	0
94	Beetle	1	0	0	0	0	0	1	0
95	Beetle	1	0	0	0	0	0	0	1
96	Beetle	1	0	0	0	0	0	0	1
97	Beetle	1	0	0	1	0	0	0	0
98	Beetle	1	0	0	1	0	0	0	0
99	Beetle	1	0	0	0	0	0	1	0
100	Beetle	1	0	0	0	0	0	1	0
101	Beetle	1	0	0	0	0	0	0	1
102	Beetle	1	0	0	0	0	0	0	1
103	Beetle	1	0	0	1	0	0	0	0
104	Beetle	1	0	0	1	0	0	0	0
105	Beetle	1	0	0	0	0	0	1	0
106	Beetle	1	0	0	0	0	0	1	0
107	Beetle	1	0	0	0	0	0	0	1
108	Beetle	1	0	0	0	0	0	0	1
109	Beetle	1	0	0	1	0	0	0	0
110	Beetle	1	0	0	1	0	0	0	0
111	Beetle	1	0	0	0	0	0	1	0
112	Beetle	1	0	0	0	0	0	1	0
113	Beetle	1	0	0	0	0	0	0	1
114	Beetle	1	0	0	0	0	0	0	1

Appendix 2

Idealized Trait Combinations		Color Brightness	Color						
Number	Pollination Syndrome	Vivid	Brown	White	Red	Green	Yellow	Blue	Purple
76	Beetle	0	1	1	0	0	0	0	0
77	Beetle	0	1	1	0	0	0	0	0
78	Beetle	0	1	1	0	0	0	0	0
79	Beetle	0	1	1	0	0	0	0	0
80	Beetle	0	1	1	0	0	0	0	0
81	Beetle	0	1	1	0	0	0	0	0
82	Beetle	0	1	1	0	0	0	0	0
83	Beetle	0	1	1	0	0	0	0	0
84	Beetle	0	1	1	0	0	0	0	0
85	Beetle	0	1	1	0	0	0	0	0
86	Beetle	0	1	1	0	0	0	0	0
87	Beetle	0	1	1	0	0	0	0	0
88	Beetle	0	1	1	0	0	0	0	0
89	Beetle	0	1	1	0	0	0	0	0
90	Beetle	0	1	1	0	0	0	0	0
91	Beetle	0	1	1	0	0	0	0	0
92	Beetle	0	1	1	0	0	0	0	0
93	Beetle	0	1	1	0	0	0	0	0
94	Beetle	0	1	1	0	0	0	0	0
95	Beetle	0	1	1	0	0	0	0	0
96	Beetle	0	1	1	0	0	0	0	0
97	Beetle	0	1	1	0	0	0	0	0
98	Beetle	0	1	1	0	0	0	0	0
99	Beetle	0	1	1	0	0	0	0	0
100	Beetle	0	1	1	0	0	0	0	0
101	Beetle	0	1	1	0	0	0	0	0
102	Beetle	0	1	1	0	0	0	0	0
103	Beetle	0	1	1	0	0	0	0	0
104	Beetle	0	1	1	0	0	0	0	0
105	Beetle	0	1	1	0	0	0	0	0
106	Beetle	0	1	1	0	0	0	0	0
107	Beetle	0	1	1	0	0	0	0	0
108	Beetle	0	1	1	0	0	0	0	0
109	Beetle	0	1	1	0	0	0	0	0
110	Beetle	0	1	1	0	0	0	0	0
111	Beetle	0	1	1	0	0	0	0	0
112	Beetle	0	1	1	0	0	0	0	0
113	Beetle	0	1	1	0	0	0	0	0
114	Beetle	0	1	1	0	0	0	0	0

Appendix 2

Idealized Trait Combinations		Flower Shape							Size	
Number	Pollination Syndrome	Trap	Open	Bell	Brush	Gullet	Flag	Tube	Medium/ Small	Mechanically Strong
115	Beetle	0	1	0	0	0	0	0	0	1
116	Beetle	0	1	0	0	0	0	0	0	1
117	Beetle	0	1	0	0	0	0	0	0	1
118	Beetle	0	1	0	0	0	0	0	0	1
119	Beetle	0	1	0	0	0	0	0	0	1
120	Beetle	0	1	0	0	0	0	0	0	1
121	Beetle	0	1	0	0	0	0	0	0	1
122	Beetle	0	1	0	0	0	0	0	0	1
123	Beetle	0	1	0	0	0	0	0	0	1
124	Beetle	0	1	0	0	0	0	0	0	1
125	Beetle	0	1	0	0	0	0	0	0	1
126	Beetle	0	1	0	0	0	0	0	0	1
127	Beetle	0	1	0	0	0	0	0	0	1
128	Beetle	0	1	0	0	0	0	0	0	1
129	Beetle	0	1	0	0	0	0	0	0	1
130	Beetle	0	1	0	0	0	0	0	0	1
131	Beetle	0	1	0	0	0	0	0	0	1
132	Beetle	0	1	0	0	0	0	0	0	1
133	Carrion Fly	1	0	0	0	0	0	0	0	0
134	Carrion Fly	1	0	0	0	0	0	0	0	0
135	Carrion Fly	1	0	0	0	0	0	0	0	0
136	Carrion Fly	1	0	0	0	0	0	0	0	0
137	Carrion Fly	1	0	0	0	0	0	0	0	0
138	Carrion Fly	1	0	0	0	0	0	0	0	0
139	Carrion Fly	1	0	0	0	0	0	0	0	0
140	Carrion Fly	1	0	0	0	0	0	0	0	0
141	Carrion Fly	1	0	0	0	0	0	0	0	0
142	Carrion Fly	0	1	0	0	0	0	0	0	0
143	Carrion Fly	0	1	0	0	0	0	0	0	0
144	Carrion Fly	0	1	0	0	0	0	0	0	0
145	Carrion Fly	0	1	0	0	0	0	0	0	0
146	Carrion Fly	0	1	0	0	0	0	0	0	0
147	Carrion Fly	0	1	0	0	0	0	0	0	0
148	Carrion Fly	0	1	0	0	0	0	0	0	0
149	Carrion Fly	0	1	0	0	0	0	0	0	0
150	Carrion Fly	0	1	0	0	0	0	0	0	0
151	Carrion Fly	0	0	1	0	0	0	0	0	0
152	Carrion Fly	0	0	1	0	0	0	0	0	0
153	Carrion Fly	0	0	1	0	0	0	0	0	0

Appendix 2

Idealized Trait Combinations		Symmetry	Anthers		Flower Orientation		
Number	Pollination Syndrome	Zygomorphic	Stiff	Exposed	Pendant	Upright	Horizontal
115	Beetle	0	0	1	0	0	1
116	Beetle	0	0	1	0	0	1
117	Beetle	0	0	1	0	0	1
118	Beetle	0	0	1	0	0	1
119	Beetle	0	0	1	0	0	1
120	Beetle	0	0	1	0	0	1
121	Beetle	0	1	1	0	0	0
122	Beetle	0	1	1	0	0	0
123	Beetle	0	1	1	0	0	0
124	Beetle	0	1	1	0	0	0
125	Beetle	0	1	1	0	0	0
126	Beetle	0	1	1	0	0	0
127	Beetle	0	1	1	0	0	0
128	Beetle	0	1	1	0	0	0
129	Beetle	0	1	1	0	0	0
130	Beetle	0	1	1	0	0	0
131	Beetle	0	1	1	0	0	0
132	Beetle	0	1	1	0	0	0
133	Carrion Fly	0	0	0	1	0	0
134	Carrion Fly	0	0	0	1	0	0
135	Carrion Fly	0	0	0	1	0	0
136	Carrion Fly	0	0	0	0	1	0
137	Carrion Fly	0	0	0	0	1	0
138	Carrion Fly	0	0	0	0	1	0
139	Carrion Fly	0	0	0	0	0	1
140	Carrion Fly	0	0	0	0	0	1
141	Carrion Fly	0	0	0	0	0	1
142	Carrion Fly	0	0	0	1	0	0
143	Carrion Fly	0	0	0	1	0	0
144	Carrion Fly	0	0	0	1	0	0
145	Carrion Fly	0	0	0	0	1	0
146	Carrion Fly	0	0	0	0	1	0
147	Carrion Fly	0	0	0	0	1	0
148	Carrion Fly	0	0	0	0	0	1
149	Carrion Fly	0	0	0	0	0	1
150	Carrion Fly	0	0	0	0	0	1
151	Carrion Fly	0	0	0	1	0	0
152	Carrion Fly	0	0	0	1	0	0
153	Carrion Fly	0	0	0	1	0	0

Appendix 2

Idealized Trait Combinations		Tube Morphology				Time of Opening	Nectar		Nectar Volume	
Number	Pollination Syndrome	Narrow	Wide	Short	Long	Day	Guides	Present	Abundant	Moderate
115	Beetle	0	0	0	0	0	0	1	0	1
116	Beetle	0	0	0	0	0	0	1	0	0
117	Beetle	0	0	0	0	0	0	1	0	1
118	Beetle	0	0	0	0	0	0	1	0	0
119	Beetle	0	0	0	0	0	0	1	0	1
120	Beetle	0	0	0	0	0	0	1	0	0
121	Beetle	0	0	0	0	1	0	1	0	1
122	Beetle	0	0	0	0	1	0	1	0	0
123	Beetle	0	0	0	0	1	0	1	0	1
124	Beetle	0	0	0	0	1	0	1	0	0
125	Beetle	0	0	0	0	1	0	1	0	1
126	Beetle	0	0	0	0	1	0	1	0	0
127	Beetle	0	0	0	0	0	0	1	0	1
128	Beetle	0	0	0	0	0	0	1	0	0
129	Beetle	0	0	0	0	0	0	1	0	1
130	Beetle	0	0	0	0	0	0	1	0	0
131	Beetle	0	0	0	0	0	0	1	0	1
132	Beetle	0	0	0	0	0	0	1	0	0
133	Carrion Fly	0	0	0	0	1	0	0	0	0
134	Carrion Fly	0	0	0	0	1	0	0	0	0
135	Carrion Fly	0	0	0	0	1	0	0	0	0
136	Carrion Fly	0	0	0	0	1	0	0	0	0
137	Carrion Fly	0	0	0	0	1	0	0	0	0
138	Carrion Fly	0	0	0	0	1	0	0	0	0
139	Carrion Fly	0	0	0	0	1	0	0	0	0
140	Carrion Fly	0	0	0	0	1	0	0	0	0
141	Carrion Fly	0	0	0	0	1	0	0	0	0
142	Carrion Fly	0	0	0	0	1	0	0	0	0
143	Carrion Fly	0	0	0	0	1	0	0	0	0
144	Carrion Fly	0	0	0	0	1	0	0	0	0
145	Carrion Fly	0	0	0	0	1	0	0	0	0
146	Carrion Fly	0	0	0	0	1	0	0	0	0
147	Carrion Fly	0	0	0	0	1	0	0	0	0
148	Carrion Fly	0	0	0	0	1	0	0	0	0
149	Carrion Fly	0	0	0	0	1	0	0	0	0
150	Carrion Fly	0	0	0	0	1	0	0	0	0
151	Carrion Fly	0	0	0	0	1	0	0	0	0
152	Carrion Fly	0	0	0	0	1	0	0	0	0
153	Carrion Fly	0	0	0	0	1	0	0	0	0

Appendix 2

Idealized Trait Combinations		Odor Strength		Scent Type					
Number	Pollination Syndrome	Strong	None	Sweet	Fruity	Fresh	Musky	Sour	Decaying
115	Beetle	1	0	0	1	0	0	0	0
116	Beetle	1	0	0	1	0	0	0	0
117	Beetle	1	0	0	0	0	0	1	0
118	Beetle	1	0	0	0	0	0	1	0
119	Beetle	1	0	0	0	0	0	0	1
120	Beetle	1	0	0	0	0	0	0	1
121	Beetle	1	0	0	1	0	0	0	0
122	Beetle	1	0	0	1	0	0	0	0
123	Beetle	1	0	0	0	0	0	1	0
124	Beetle	1	0	0	0	0	0	1	0
125	Beetle	1	0	0	0	0	0	0	1
126	Beetle	1	0	0	0	0	0	0	1
127	Beetle	1	0	0	1	0	0	0	0
128	Beetle	1	0	0	1	0	0	0	0
129	Beetle	1	0	0	0	0	0	1	0
130	Beetle	1	0	0	0	0	0	1	0
131	Beetle	1	0	0	0	0	0	0	1
132	Beetle	1	0	0	0	0	0	0	1
133	Carrion Fly	1	0	0	0	0	0	0	1
134	Carrion Fly	1	0	0	0	0	0	0	1
135	Carrion Fly	1	0	0	0	0	0	0	1
136	Carrion Fly	1	0	0	0	0	0	0	1
137	Carrion Fly	1	0	0	0	0	0	0	1
138	Carrion Fly	1	0	0	0	0	0	0	1
139	Carrion Fly	1	0	0	0	0	0	0	1
140	Carrion Fly	1	0	0	0	0	0	0	1
141	Carrion Fly	1	0	0	0	0	0	0	1
142	Carrion Fly	1	0	0	0	0	0	0	1
143	Carrion Fly	1	0	0	0	0	0	0	1
144	Carrion Fly	1	0	0	0	0	0	0	1
145	Carrion Fly	1	0	0	0	0	0	0	1
146	Carrion Fly	1	0	0	0	0	0	0	1
147	Carrion Fly	1	0	0	0	0	0	0	1
148	Carrion Fly	1	0	0	0	0	0	0	1
149	Carrion Fly	1	0	0	0	0	0	0	1
150	Carrion Fly	1	0	0	0	0	0	0	1
151	Carrion Fly	1	0	0	0	0	0	0	1
152	Carrion Fly	1	0	0	0	0	0	0	1
153	Carrion Fly	1	0	0	0	0	0	0	1

Appendix 2

Idealized Trait Combinations		Color Brightness	Color						
Number	Pollination Syndrome	Vivid	Brown	White	Red	Green	Yellow	Blue	Purple
115	Beetle	0	1	1	0	0	0	0	0
116	Beetle	0	1	1	0	0	0	0	0
117	Beetle	0	1	1	0	0	0	0	0
118	Beetle	0	1	1	0	0	0	0	0
119	Beetle	0	1	1	0	0	0	0	0
120	Beetle	0	1	1	0	0	0	0	0
121	Beetle	0	1	1	0	0	0	0	0
122	Beetle	0	1	1	0	0	0	0	0
123	Beetle	0	1	1	0	0	0	0	0
124	Beetle	0	1	1	0	0	0	0	0
125	Beetle	0	1	1	0	0	0	0	0
126	Beetle	0	1	1	0	0	0	0	0
127	Beetle	0	1	1	0	0	0	0	0
128	Beetle	0	1	1	0	0	0	0	0
129	Beetle	0	1	1	0	0	0	0	0
130	Beetle	0	1	1	0	0	0	0	0
131	Beetle	0	1	1	0	0	0	0	0
132	Beetle	0	1	1	0	0	0	0	0
133	Carrion Fly	0	1	0	0	0	0	0	0
134	Carrion Fly	0	0	0	0	1	0	0	0
135	Carrion Fly	0	0	0	0	0	0	0	1
136	Carrion Fly	0	1	0	0	0	0	0	0
137	Carrion Fly	0	0	0	0	1	0	0	0
138	Carrion Fly	0	0	0	0	0	0	0	1
139	Carrion Fly	0	1	0	0	0	0	0	0
140	Carrion Fly	0	0	0	0	1	0	0	0
141	Carrion Fly	0	0	0	0	0	0	0	1
142	Carrion Fly	0	1	0	0	0	0	0	0
143	Carrion Fly	0	0	0	0	1	0	0	0
144	Carrion Fly	0	0	0	0	0	0	0	1
145	Carrion Fly	0	1	0	0	0	0	0	0
146	Carrion Fly	0	0	0	0	1	0	0	0
147	Carrion Fly	0	0	0	0	0	0	0	1
148	Carrion Fly	0	1	0	0	0	0	0	0
149	Carrion Fly	0	0	0	0	1	0	0	0
150	Carrion Fly	0	0	0	0	0	0	0	1
151	Carrion Fly	0	1	0	0	0	0	0	0
152	Carrion Fly	0	0	0	0	1	0	0	0
153	Carrion Fly	0	0	0	0	0	0	0	1

Appendix 2

Idealized Trait Combinations		Flower Shape							Size	
Number	Pollination Syndrome	Trap	Open	Bell	Brush	Gullet	Flag	Tube	Medium/ Small	Mechanically Strong
154	Carrion Fly	0	0	1	0	0	0	0	0	0
155	Carrion Fly	0	0	1	0	0	0	0	0	0
156	Carrion Fly	0	0	1	0	0	0	0	0	0
157	Carrion Fly	0	0	1	0	0	0	0	0	0
158	Carrion Fly	0	0	1	0	0	0	0	0	0
159	Carrion Fly	0	0	1	0	0	0	0	0	0
160	Bee	0	0	1	0	0	0	0	1	1
161	Bee	0	0	1	0	0	0	0	1	1
162	Bee	0	0	1	0	0	0	0	1	1
163	Bee	0	0	1	0	0	0	0	1	1
164	Bee	0	0	1	0	0	0	0	1	1
165	Bee	0	0	1	0	0	0	0	1	1
166	Bee	0	0	1	0	0	0	0	1	1
167	Bee	0	0	1	0	0	0	0	1	1
168	Bee	0	0	1	0	0	0	0	1	1
169	Bee	0	0	1	0	0	0	0	1	1
170	Bee	0	0	1	0	0	0	0	1	1
171	Bee	0	0	1	0	0	0	0	1	1
172	Bee	0	0	1	0	0	0	0	1	1
173	Bee	0	0	1	0	0	0	0	1	1
174	Bee	0	0	1	0	0	0	0	1	1
175	Bee	0	0	1	0	0	0	0	1	1
176	Bee	0	0	1	0	0	0	0	1	1
177	Bee	0	0	1	0	0	0	0	1	1
178	Bee	0	0	1	0	0	0	0	1	1
179	Bee	0	0	1	0	0	0	0	1	1
180	Bee	0	0	1	0	0	0	0	1	1
181	Bee	0	0	1	0	0	0	0	1	1
182	Bee	0	0	1	0	0	0	0	1	1
183	Bee	0	0	1	0	0	0	0	1	1
184	Bee	0	0	0	1	0	0	0	1	1
185	Bee	0	0	0	1	0	0	0	1	1
186	Bee	0	0	0	1	0	0	0	1	1
187	Bee	0	0	0	1	0	0	0	1	1
188	Bee	0	0	0	1	0	0	0	1	1
189	Bee	0	0	0	1	0	0	0	1	1
190	Bee	0	0	0	1	0	0	0	1	1
191	Bee	0	0	0	1	0	0	0	1	1
192	Bee	0	0	0	1	0	0	0	1	1

Appendix 2

Idealized Trait Combinations		Symmetry	Anthers		Flower Orientation		
Number	Pollination Syndrome	Zygomorphic	Stiff	Exposed	Pendant	Upright	Horizontal
154	Carrion Fly	0	0	0	0	1	0
155	Carrion Fly	0	0	0	0	1	0
156	Carrion Fly	0	0	0	0	1	0
157	Carrion Fly	0	0	0	0	0	1
158	Carrion Fly	0	0	0	0	0	1
159	Carrion Fly	0	0	0	0	0	1
160	Bee	1	0	0	1	0	0
161	Bee	1	0	0	1	0	0
162	Bee	1	0	0	1	0	0
163	Bee	1	0	0	1	0	0
164	Bee	1	0	0	1	0	0
165	Bee	1	0	0	1	0	0
166	Bee	1	0	0	1	0	0
167	Bee	1	0	0	1	0	0
168	Bee	1	0	0	0	1	0
169	Bee	1	0	0	0	1	0
170	Bee	1	0	0	0	1	0
171	Bee	1	0	0	0	1	0
172	Bee	1	0	0	0	1	0
173	Bee	1	0	0	0	1	0
174	Bee	1	0	0	0	1	0
175	Bee	1	0	0	0	1	0
176	Bee	1	0	0	0	0	1
177	Bee	1	0	0	0	0	1
178	Bee	1	0	0	0	0	1
179	Bee	1	0	0	0	0	1
180	Bee	1	0	0	0	0	1
181	Bee	1	0	0	0	0	1
182	Bee	1	0	0	0	0	1
183	Bee	1	0	0	0	0	1
184	Bee	1	0	0	1	0	0
185	Bee	1	0	0	1	0	0
186	Bee	1	0	0	1	0	0
187	Bee	1	0	0	1	0	0
188	Bee	1	0	0	1	0	0
189	Bee	1	0	0	1	0	0
190	Bee	1	0	0	1	0	0
191	Bee	1	0	0	1	0	0
192	Bee	1	0	0	0	1	0

Appendix 2

Idealized Trait Combinations		Tube Morphology				Time of Opening	Nectar		Nectar Volume	
Number	Pollination Syndrome	Narrow	Wide	Short	Long	Day	Guides	Present	Abundant	Moderate
154	Carrion Fly	0	0	0	0	1	0	0	0	0
155	Carrion Fly	0	0	0	0	1	0	0	0	0
156	Carrion Fly	0	0	0	0	1	0	0	0	0
157	Carrion Fly	0	0	0	0	1	0	0	0	0
158	Carrion Fly	0	0	0	0	1	0	0	0	0
159	Carrion Fly	0	0	0	0	1	0	0	0	0
160	Bee	1	0	1	0	1	1	1	0	1
161	Bee	1	0	1	0	1	1	1	0	1
162	Bee	1	0	1	0	1	1	1	0	1
163	Bee	1	0	1	0	1	1	1	0	1
164	Bee	0	1	1	0	1	1	1	0	1
165	Bee	0	1	1	0	1	1	1	0	1
166	Bee	0	1	1	0	1	1	1	0	1
167	Bee	0	1	1	0	1	1	1	0	1
168	Bee	1	0	1	0	1	1	1	0	1
169	Bee	1	0	1	0	1	1	1	0	1
170	Bee	1	0	1	0	1	1	1	0	1
171	Bee	1	0	1	0	1	1	1	0	1
172	Bee	0	1	1	0	1	1	1	0	1
173	Bee	0	1	1	0	1	1	1	0	1
174	Bee	0	1	1	0	1	1	1	0	1
175	Bee	0	1	1	0	1	1	1	0	1
176	Bee	1	0	1	0	1	1	1	0	1
177	Bee	1	0	1	0	1	1	1	0	1
178	Bee	1	0	1	0	1	1	1	0	1
179	Bee	1	0	1	0	1	1	1	0	1
180	Bee	0	1	1	0	1	1	1	0	1
181	Bee	0	1	1	0	1	1	1	0	1
182	Bee	0	1	1	0	1	1	1	0	1
183	Bee	0	1	1	0	1	1	1	0	1
184	Bee	1	0	1	0	1	1	1	0	1
185	Bee	1	0	1	0	1	1	1	0	1
186	Bee	1	0	1	0	1	1	1	0	1
187	Bee	1	0	1	0	1	1	1	0	1
188	Bee	0	1	1	0	1	1	1	0	1
189	Bee	0	1	1	0	1	1	1	0	1
190	Bee	0	1	1	0	1	1	1	0	1
191	Bee	0	1	1	0	1	1	1	0	1
192	Bee	1	0	1	0	1	1	1	0	1

Appendix 2

Idealized Trait Combinations		Odor Strength		Scent Type					
Number	Pollination Syndrome	Strong	None	Sweet	Fruity	Fresh	Musky	Sour	Decaying
154	Carrion Fly	1	0	0	0	0	0	0	1
155	Carrion Fly	1	0	0	0	0	0	0	1
156	Carrion Fly	1	0	0	0	0	0	0	1
157	Carrion Fly	1	0	0	0	0	0	0	1
158	Carrion Fly	1	0	0	0	0	0	0	1
159	Carrion Fly	1	0	0	0	0	0	0	1
160	Bee	0	0	0	0	1	0	0	0
161	Bee	0	0	0	0	1	0	0	0
162	Bee	0	0	0	0	1	0	0	0
163	Bee	0	0	0	0	1	0	0	0
164	Bee	0	0	0	0	1	0	0	0
165	Bee	0	0	0	0	1	0	0	0
166	Bee	0	0	0	0	1	0	0	0
167	Bee	0	0	0	0	1	0	0	0
168	Bee	0	0	0	0	1	0	0	0
169	Bee	0	0	0	0	1	0	0	0
170	Bee	0	0	0	0	1	0	0	0
171	Bee	0	0	0	0	1	0	0	0
172	Bee	0	0	0	0	1	0	0	0
173	Bee	0	0	0	0	1	0	0	0
174	Bee	0	0	0	0	1	0	0	0
175	Bee	0	0	0	0	1	0	0	0
176	Bee	0	0	0	0	1	0	0	0
177	Bee	0	0	0	0	1	0	0	0
178	Bee	0	0	0	0	1	0	0	0
179	Bee	0	0	0	0	1	0	0	0
180	Bee	0	0	0	0	1	0	0	0
181	Bee	0	0	0	0	1	0	0	0
182	Bee	0	0	0	0	1	0	0	0
183	Bee	0	0	0	0	1	0	0	0
184	Bee	0	0	0	0	1	0	0	0
185	Bee	0	0	0	0	1	0	0	0
186	Bee	0	0	0	0	1	0	0	0
187	Bee	0	0	0	0	1	0	0	0
188	Bee	0	0	0	0	1	0	0	0
189	Bee	0	0	0	0	1	0	0	0
190	Bee	0	0	0	0	1	0	0	0
191	Bee	0	0	0	0	1	0	0	0
192	Bee	0	0	0	0	1	0	0	0

Appendix 2

Idealized Trait Combinations		Color Brightness	Color						
Number	Pollination Syndrome	Vivid	Brown	White	Red	Green	Yellow	Blue	Purple
154	Carrion Fly	0	1	0	0	0	0	0	0
155	Carrion Fly	0	0	0	0	1	0	0	0
156	Carrion Fly	0	0	0	0	0	0	0	1
157	Carrion Fly	0	1	0	0	0	0	0	0
158	Carrion Fly	0	0	0	0	1	0	0	0
159	Carrion Fly	0	0	0	0	0	0	0	1
160	Bee	1	0	1	0	0	0	0	0
161	Bee	1	0	0	0	0	1	0	0
162	Bee	1	0	0	0	0	0	1	0
163	Bee	1	0	0	0	0	0	0	1
164	Bee	1	0	1	0	0	0	0	0
165	Bee	1	0	0	0	0	1	0	0
166	Bee	1	0	0	0	0	0	1	0
167	Bee	1	0	0	0	0	0	0	1
168	Bee	1	0	1	0	0	0	0	0
169	Bee	1	0	0	0	0	1	0	0
170	Bee	1	0	0	0	0	0	1	0
171	Bee	1	0	0	0	0	0	0	1
172	Bee	1	0	1	0	0	0	0	0
173	Bee	1	0	0	0	0	1	0	0
174	Bee	1	0	0	0	0	0	1	0
175	Bee	1	0	0	0	0	0	0	1
176	Bee	1	0	1	0	0	0	0	0
177	Bee	1	0	0	0	0	1	0	0
178	Bee	1	0	0	0	0	0	1	0
179	Bee	1	0	0	0	0	0	0	1
180	Bee	1	0	1	0	0	0	0	0
181	Bee	1	0	0	0	0	1	0	0
182	Bee	1	0	0	0	0	0	1	0
183	Bee	1	0	0	0	0	0	0	1
184	Bee	1	0	1	0	0	0	0	0
185	Bee	1	0	0	0	0	1	0	0
186	Bee	1	0	0	0	0	0	1	0
187	Bee	1	0	0	0	0	0	0	1
188	Bee	1	0	1	0	0	0	0	0
189	Bee	1	0	0	0	0	1	0	0
190	Bee	1	0	0	0	0	0	1	0
191	Bee	1	0	0	0	0	0	0	1
192	Bee	1	0	0	0	0	1	0	0

Appendix 2

Idealized Trait Combinations		Flower Shape							Size	
Number	Pollination Syndrome	Trap	Open	Bell	Brush	Gullet	Flag	Tube	Medium/ Small	Mechanically Strong
193	Bee	0	0	0	1	0	0	0	1	1
194	Bee	0	0	0	1	0	0	0	1	1
195	Bee	0	0	0	1	0	0	0	1	1
196	Bee	0	0	0	1	0	0	0	1	1
197	Bee	0	0	0	1	0	0	0	1	1
198	Bee	0	0	0	1	0	0	0	1	1
199	Bee	0	0	0	1	0	0	0	1	1
200	Bee	0	0	0	1	0	0	0	1	1
201	Bee	0	0	0	1	0	0	0	1	1
202	Bee	0	0	0	1	0	0	0	1	1
203	Bee	0	0	0	1	0	0	0	1	1
204	Bee	0	0	0	1	0	0	0	1	1
205	Bee	0	0	0	1	0	0	0	1	1
206	Bee	0	0	0	1	0	0	0	1	1
207	Bee	0	0	0	1	0	0	0	1	1
208	Bee	0	0	0	0	1	0	0	1	1
209	Bee	0	0	0	0	1	0	0	1	1
210	Bee	0	0	0	0	1	0	0	1	1
211	Bee	0	0	0	0	1	0	0	1	1
212	Bee	0	0	0	0	1	0	0	1	1
213	Bee	0	0	0	0	1	0	0	1	1
214	Bee	0	0	0	0	1	0	0	1	1
215	Bee	0	0	0	0	1	0	0	1	1
216	Bee	0	0	0	0	1	0	0	1	1
217	Bee	0	0	0	0	1	0	0	1	1
218	Bee	0	0	0	0	1	0	0	1	1
219	Bee	0	0	0	0	1	0	0	1	1
220	Bee	0	0	0	0	1	0	0	1	1
221	Bee	0	0	0	0	1	0	0	1	1
222	Bee	0	0	0	0	1	0	0	1	1
223	Bee	0	0	0	0	1	0	0	1	1
224	Bee	0	0	0	0	1	0	0	1	1
225	Bee	0	0	0	0	1	0	0	1	1
226	Bee	0	0	0	0	1	0	0	1	1
227	Bee	0	0	0	0	1	0	0	1	1
228	Bee	0	0	0	0	1	0	0	1	1
229	Bee	0	0	0	0	1	0	0	1	1
230	Bee	0	0	0	0	1	0	0	1	1
231	Bee	0	0	0	0	1	0	0	1	1

Appendix 2

Idealized Trait Combinations		Symmetry	Anthers		Flower Orientation		
Number	Pollination Syndrome	Zygomorphic	Stiff	Exposed	Pendant	Upright	Horizontal
193	Bee	1	0	0	0	1	0
194	Bee	1	0	0	0	1	0
195	Bee	1	0	0	0	1	0
196	Bee	1	0	0	0	1	0
197	Bee	1	0	0	0	1	0
198	Bee	1	0	0	0	1	0
199	Bee	1	0	0	0	0	1
200	Bee	1	0	0	0	0	1
201	Bee	1	0	0	0	0	1
202	Bee	1	0	0	0	0	1
203	Bee	1	0	0	0	0	1
204	Bee	1	0	0	0	0	1
205	Bee	1	0	0	0	0	1
206	Bee	1	0	0	0	0	1
207	Bee	1	0	0	0	0	1
208	Bee	1	0	0	1	0	0
209	Bee	1	0	0	1	0	0
210	Bee	1	0	0	1	0	0
211	Bee	1	0	0	1	0	0
212	Bee	1	0	0	1	0	0
213	Bee	1	0	0	1	0	0
214	Bee	1	0	0	1	0	0
215	Bee	1	0	0	1	0	0
216	Bee	1	0	0	0	1	0
217	Bee	1	0	0	0	1	0
218	Bee	1	0	0	0	1	0
219	Bee	1	0	0	0	1	0
220	Bee	1	0	0	0	1	0
221	Bee	1	0	0	0	1	0
222	Bee	1	0	0	0	1	0
223	Bee	1	0	0	0	1	0
224	Bee	1	0	0	0	0	1
225	Bee	1	0	0	0	0	1
226	Bee	1	0	0	0	0	1
227	Bee	1	0	0	0	0	1
228	Bee	1	0	0	0	0	1
229	Bee	1	0	0	0	0	1
230	Bee	1	0	0	0	0	1
231	Bee	1	0	0	0	0	1

Appendix 2

Idealized Trait Combinations		Tube Morphology				Time of Opening	Nectar		Nectar Volume	
Number	Pollination Syndrome	Narrow	Wide	Short	Long	Day	Guides	Present	Abundant	Moderate
193	Bee	1	0	1	0	1	1	1	0	1
194	Bee	1	0	1	0	1	1	1	0	1
195	Bee	0	1	1	0	1	1	1	0	1
196	Bee	0	1	1	0	1	1	1	0	1
197	Bee	0	1	1	0	1	1	1	0	1
198	Bee	0	1	1	0	1	1	1	0	1
199	Bee	1	0	1	0	1	1	1	0	1
200	Bee	1	0	1	0	1	1	1	0	1
201	Bee	1	0	1	0	1	1	1	0	1
202	Bee	1	0	1	0	1	1	1	0	1
203	Bee	1	0	1	0	1	1	1	0	1
204	Bee	0	1	1	0	1	1	1	0	1
205	Bee	0	1	1	0	1	1	1	0	1
206	Bee	0	1	1	0	1	1	1	0	1
207	Bee	0	1	1	0	1	1	1	0	1
208	Bee	1	0	1	0	1	1	1	0	1
209	Bee	1	0	1	0	1	1	1	0	1
210	Bee	1	0	1	0	1	1	1	0	1
211	Bee	1	0	1	0	1	1	1	0	1
212	Bee	0	1	1	0	1	1	1	0	1
213	Bee	0	1	1	0	1	1	1	0	1
214	Bee	0	1	1	0	1	1	1	0	1
215	Bee	0	1	1	0	1	1	1	0	1
216	Bee	1	0	1	0	1	1	1	0	1
217	Bee	1	0	1	0	1	1	1	0	1
218	Bee	1	0	1	0	1	1	1	0	1
219	Bee	1	0	1	0	1	1	1	0	1
220	Bee	0	1	1	0	1	1	1	0	1
221	Bee	0	1	1	0	1	1	1	0	1
222	Bee	0	1	1	0	1	1	1	0	1
223	Bee	0	1	1	0	1	1	1	0	1
224	Bee	1	0	1	0	1	1	1	0	1
225	Bee	1	0	1	0	1	1	1	0	1
226	Bee	1	0	1	0	1	1	1	0	1
227	Bee	1	0	1	0	1	1	1	0	1
228	Bee	0	1	1	0	1	1	1	0	1
229	Bee	0	1	1	0	1	1	1	0	1
230	Bee	0	1	1	0	1	1	1	0	1
231	Bee	0	1	1	0	1	1	1	0	1

Appendix 2

Idealized Trait Combinations		Odor Strength		Scent Type					
Number	Pollination Syndrome	Strong	None	Sweet	Fruity	Fresh	Musky	Sour	Decaying
193	Bee	0	0	0	0	1	0	0	0
194	Bee	0	0	0	0	1	0	0	0
195	Bee	0	0	0	0	1	0	0	0
196	Bee	0	0	0	0	1	0	0	0
197	Bee	0	0	0	0	1	0	0	0
198	Bee	0	0	0	0	1	0	0	0
199	Bee	0	0	0	0	1	0	0	0
200	Bee	0	0	0	0	1	0	0	0
201	Bee	0	0	0	0	1	0	0	0
202	Bee	0	0	0	0	1	0	0	0
203	Bee	0	0	0	0	1	0	0	0
204	Bee	0	0	0	0	1	0	0	0
205	Bee	0	0	0	0	1	0	0	0
206	Bee	0	0	0	0	1	0	0	0
207	Bee	0	0	0	0	1	0	0	0
208	Bee	0	0	0	0	1	0	0	0
209	Bee	0	0	0	0	1	0	0	0
210	Bee	0	0	0	0	1	0	0	0
211	Bee	0	0	0	0	1	0	0	0
212	Bee	0	0	0	0	1	0	0	0
213	Bee	0	0	0	0	1	0	0	0
214	Bee	0	0	0	0	1	0	0	0
215	Bee	0	0	0	0	1	0	0	0
216	Bee	0	0	0	0	1	0	0	0
217	Bee	0	0	0	0	1	0	0	0
218	Bee	0	0	0	0	1	0	0	0
219	Bee	0	0	0	0	1	0	0	0
220	Bee	0	0	0	0	1	0	0	0
221	Bee	0	0	0	0	1	0	0	0
222	Bee	0	0	0	0	1	0	0	0
223	Bee	0	0	0	0	1	0	0	0
224	Bee	0	0	0	0	1	0	0	0
225	Bee	0	0	0	0	1	0	0	0
226	Bee	0	0	0	0	1	0	0	0
227	Bee	0	0	0	0	1	0	0	0
228	Bee	0	0	0	0	1	0	0	0
229	Bee	0	0	0	0	1	0	0	0
230	Bee	0	0	0	0	1	0	0	0
231	Bee	0	0	0	0	1	0	0	0

Appendix 2

Idealized Trait Combinations		Color Brightness	Color						
Number	Pollination Syndrome	Vivid	Brown	White	Red	Green	Yellow	Blue	Purple
193	Bee	1	0	0	0	0	0	1	0
194	Bee	1	0	0	0	0	0	0	1
195	Bee	1	0	1	0	0	0	0	0
196	Bee	1	0	0	0	0	1	0	0
197	Bee	1	0	0	0	0	0	1	0
198	Bee	1	0	0	0	0	0	0	1
199	Bee	1	0	1	0	0	0	0	0
200	Bee	1	0	0	0	0	1	0	0
201	Bee	1	0	0	0	0	0	1	0
202	Bee	1	0	0	0	0	0	1	0
203	Bee	1	0	0	0	0	0	0	1
204	Bee	1	0	1	0	0	0	0	0
205	Bee	1	0	0	0	0	1	0	0
206	Bee	1	0	0	0	0	0	1	0
207	Bee	1	0	0	0	0	0	0	1
208	Bee	1	0	1	0	0	0	0	0
209	Bee	1	0	0	0	0	1	0	0
210	Bee	1	0	0	0	0	0	1	0
211	Bee	1	0	0	0	0	0	0	1
212	Bee	1	0	1	0	0	0	0	0
213	Bee	1	0	0	0	0	1	0	0
214	Bee	1	0	0	0	0	0	1	0
215	Bee	1	0	0	0	0	0	0	1
216	Bee	1	0	1	0	0	0	0	0
217	Bee	1	0	0	0	0	1	0	0
218	Bee	1	0	0	0	0	0	1	0
219	Bee	1	0	0	0	0	0	0	1
220	Bee	1	0	1	0	0	0	0	0
221	Bee	1	0	0	0	0	1	0	0
222	Bee	1	0	0	0	0	0	1	0
223	Bee	1	0	0	0	0	0	0	1
224	Bee	1	0	1	0	0	0	0	0
225	Bee	1	0	0	0	0	1	0	0
226	Bee	1	0	0	0	0	0	1	0
227	Bee	1	0	0	0	0	0	0	1
228	Bee	1	0	1	0	0	0	0	0
229	Bee	1	0	0	0	0	1	0	0
230	Bee	1	0	0	0	0	0	1	0
231	Bee	1	0	0	0	0	0	0	1

Appendix 2

Idealized Trait Combinations		Flower Shape							Size	
Number	Pollination Syndrome	Trap	Open	Bell	Brush	Gullet	Flag	Tube	Medium/ Small	Mechanically Strong
232	Bee	0	0	0	0	0	1	0	1	1
233	Bee	0	0	0	0	0	1	0	1	1
234	Bee	0	0	0	0	0	1	0	1	1
235	Bee	0	0	0	0	0	1	0	1	1
236	Bee	0	0	0	0	0	1	0	1	1
237	Bee	0	0	0	0	0	1	0	1	1
238	Bee	0	0	0	0	0	1	0	1	1
239	Bee	0	0	0	0	0	1	0	1	1
240	Bee	0	0	0	0	0	1	0	1	1
241	Bee	0	0	0	0	0	1	0	1	1
242	Bee	0	0	0	0	0	1	0	1	1
243	Bee	0	0	0	0	0	1	0	1	1
244	Bee	0	0	0	0	0	1	0	1	1
245	Bee	0	0	0	0	0	1	0	1	1
246	Bee	0	0	0	0	0	1	0	1	1
247	Bee	0	0	0	0	0	1	0	1	1
248	Bee	0	0	0	0	0	1	0	1	1
249	Bee	0	0	0	0	0	1	0	1	1
250	Bee	0	0	0	0	0	1	0	1	1
251	Bee	0	0	0	0	0	1	0	1	1
252	Bee	0	0	0	0	0	1	0	1	1
253	Bee	0	0	0	0	0	1	0	1	1
254	Bee	0	0	0	0	0	1	0	1	1
255	Bee	0	0	0	0	0	0	1	1	1
256	Bee	0	0	0	0	0	0	1	1	1
257	Bee	0	0	0	0	0	0	1	1	1
258	Bee	0	0	0	0	0	0	1	1	1
259	Bee	0	0	0	0	0	0	1	1	1
260	Bee	0	0	0	0	0	0	1	1	1
261	Bee	0	0	0	0	0	0	1	1	1
262	Bee	0	0	0	0	0	0	1	1	1
263	Bee	0	0	0	0	0	0	1	1	1
264	Bee	0	0	0	0	0	0	1	1	1
265	Bee	0	0	0	0	0	0	1	1	1
266	Bee	0	0	0	0	0	0	1	1	1
267	Bee	0	0	0	0	0	0	1	1	1
268	Bee	0	0	0	0	0	0	1	1	1
269	Bee	0	0	0	0	0	0	1	1	1
270	Bee	0	0	0	0	0	0	1	1	1

Appendix 2

Idealized Trait Combinations		Symmetry	Anthers		Flower Orientation		
Number	Pollination Syndrome	Zygomorphic	Stiff	Exposed	Pendant	Upright	Horizontal
232	Bee	1	0	0	1	0	0
233	Bee	1	0	0	1	0	0
234	Bee	1	0	0	1	0	0
235	Bee	1	0	0	1	0	0
236	Bee	1	0	0	1	0	0
237	Bee	1	0	0	1	0	0
238	Bee	1	0	0	1	0	0
239	Bee	1	0	0	1	0	0
240	Bee	1	0	0	0	1	0
241	Bee	1	0	0	0	1	0
242	Bee	1	0	0	0	1	0
243	Bee	1	0	0	0	1	0
244	Bee	1	0	0	0	1	0
245	Bee	1	0	0	0	1	0
246	Bee	1	0	0	0	1	0
247	Bee	1	0	0	0	1	0
248	Bee	1	0	0	0	0	1
249	Bee	1	0	0	0	0	1
250	Bee	1	0	0	0	0	1
251	Bee	1	0	0	0	0	1
252	Bee	1	0	0	0	0	1
253	Bee	1	0	0	0	0	1
254	Bee	1	0	0	0	0	1
255	Bee	1	0	0	1	0	0
256	Bee	1	0	0	1	0	0
257	Bee	1	0	0	1	0	0
258	Bee	1	0	0	1	0	0
259	Bee	1	0	0	1	0	0
260	Bee	1	0	0	1	0	0
261	Bee	1	0	0	1	0	0
262	Bee	1	0	0	1	0	0
263	Bee	1	0	0	0	1	0
264	Bee	1	0	0	0	1	0
265	Bee	1	0	0	0	1	0
266	Bee	1	0	0	0	1	0
267	Bee	1	0	0	0	1	0
268	Bee	1	0	0	0	1	0
269	Bee	1	0	0	0	1	0
270	Bee	1	0	0	0	1	0

Appendix 2

Idealized Trait Combinations		Tube Morphology				Time of Opening	Nectar		Nectar Volume	
Number	Pollination Syndrome	Narrow	Wide	Short	Long	Day	Guides	Present	Abundant	Moderate
232	Bee	1	0	1	0	1	1	1	0	1
233	Bee	1	0	1	0	1	1	1	0	1
234	Bee	1	0	1	0	1	1	1	0	1
235	Bee	1	0	1	0	1	1	1	0	1
236	Bee	1	0	1	0	1	1	1	0	1
237	Bee	0	1	1	0	1	1	1	0	1
238	Bee	0	1	1	0	1	1	1	0	1
239	Bee	0	1	1	0	1	1	1	0	1
240	Bee	1	0	1	0	1	1	1	0	1
241	Bee	1	0	1	0	1	1	1	0	1
242	Bee	1	0	1	0	1	1	1	0	1
243	Bee	1	0	1	0	1	1	1	0	1
244	Bee	0	1	1	0	1	1	1	0	1
245	Bee	0	1	1	0	1	1	1	0	1
246	Bee	0	1	1	0	1	1	1	0	1
247	Bee	0	1	1	0	1	1	1	0	1
248	Bee	1	0	1	0	1	1	1	0	1
249	Bee	1	0	1	0	1	1	1	0	1
250	Bee	1	0	1	0	1	1	1	0	1
251	Bee	1	0	1	0	1	1	1	0	1
252	Bee	0	1	1	0	1	1	1	0	1
253	Bee	0	1	1	0	1	1	1	0	1
254	Bee	0	1	1	0	1	1	1	0	1
255	Bee	1	0	1	0	1	1	1	0	1
256	Bee	1	0	1	0	1	1	1	0	1
257	Bee	1	0	1	0	1	1	1	0	1
258	Bee	1	0	1	0	1	1	1	0	1
259	Bee	0	1	1	0	1	1	1	0	1
260	Bee	0	1	1	0	1	1	1	0	1
261	Bee	0	1	1	0	1	1	1	0	1
262	Bee	0	1	1	0	1	1	1	0	1
263	Bee	1	0	1	0	1	1	1	0	1
264	Bee	1	0	1	0	1	1	1	0	1
265	Bee	1	0	1	0	1	1	1	0	1
266	Bee	1	0	1	0	1	1	1	0	1
267	Bee	0	1	1	0	1	1	1	0	1
268	Bee	0	1	1	0	1	1	1	0	1
269	Bee	0	1	1	0	1	1	1	0	1
270	Bee	0	1	1	0	1	1	1	0	1

Appendix 2

Idealized Trait Combinations		Odor Strength		Scent Type					
Number	Pollination Syndrome	Strong	None	Sweet	Fruity	Fresh	Musky	Sour	Decaying
232	Bee	0	0	0	0	1	0	0	0
233	Bee	0	0	0	0	1	0	0	0
234	Bee	0	0	0	0	1	0	0	0
235	Bee	0	0	0	0	1	0	0	0
236	Bee	0	0	0	0	1	0	0	0
237	Bee	0	0	0	0	1	0	0	0
238	Bee	0	0	0	0	1	0	0	0
239	Bee	0	0	0	0	1	0	0	0
240	Bee	0	0	0	0	1	0	0	0
241	Bee	0	0	0	0	1	0	0	0
242	Bee	0	0	0	0	1	0	0	0
243	Bee	0	0	0	0	1	0	0	0
244	Bee	0	0	0	0	1	0	0	0
245	Bee	0	0	0	0	1	0	0	0
246	Bee	0	0	0	0	1	0	0	0
247	Bee	0	0	0	0	1	0	0	0
248	Bee	0	0	0	0	1	0	0	0
249	Bee	0	0	0	0	1	0	0	0
250	Bee	0	0	0	0	1	0	0	0
251	Bee	0	0	0	0	1	0	0	0
252	Bee	0	0	0	0	1	0	0	0
253	Bee	0	0	0	0	1	0	0	0
254	Bee	0	0	0	0	1	0	0	0
255	Bee	0	0	0	0	1	0	0	0
256	Bee	0	0	0	0	1	0	0	0
257	Bee	0	0	0	0	1	0	0	0
258	Bee	0	0	0	0	1	0	0	0
259	Bee	0	0	0	0	1	0	0	0
260	Bee	0	0	0	0	1	0	0	0
261	Bee	0	0	0	0	1	0	0	0
262	Bee	0	0	0	0	1	0	0	0
263	Bee	0	0	0	0	1	0	0	0
264	Bee	0	0	0	0	1	0	0	0
265	Bee	0	0	0	0	1	0	0	0
266	Bee	0	0	0	0	1	0	0	0
267	Bee	0	0	0	0	1	0	0	0
268	Bee	0	0	0	0	1	0	0	0
269	Bee	0	0	0	0	1	0	0	0
270	Bee	0	0	0	0	1	0	0	0

Appendix 2

Idealized Trait Combinations		Color Brightness	Color						
Number	Pollination Syndrome	Vivid	Brown	White	Red	Green	Yellow	Blue	Purple
232	Bee	1	0	1	0	0	0	0	0
233	Bee	1	0	0	0	0	1	0	0
234	Bee	1	0	0	0	0	0	1	0
235	Bee	1	0	0	0	0	0	0	1
236	Bee	1	0	0	0	0	0	0	1
237	Bee	1	0	1	0	0	0	0	0
238	Bee	1	0	0	0	0	1	0	0
239	Bee	1	0	0	0	0	0	1	0
240	Bee	1	0	1	0	0	0	0	0
241	Bee	1	0	0	0	0	1	0	0
242	Bee	1	0	0	0	0	0	1	0
243	Bee	1	0	0	0	0	0	0	1
244	Bee	1	0	1	0	0	0	0	0
245	Bee	1	0	0	0	0	1	0	0
246	Bee	1	0	0	0	0	0	1	0
247	Bee	1	0	0	0	0	0	0	1
248	Bee	1	0	1	0	0	0	0	0
249	Bee	1	0	0	0	0	1	0	0
250	Bee	1	0	0	0	0	0	1	0
251	Bee	1	0	0	0	0	0	0	1
252	Bee	1	0	0	0	0	1	0	0
253	Bee	1	0	0	0	0	0	1	0
254	Bee	1	0	0	0	0	0	0	1
255	Bee	1	0	1	0	0	0	0	0
256	Bee	1	0	0	0	0	1	0	0
257	Bee	1	0	0	0	0	0	1	0
258	Bee	1	0	0	0	0	0	0	1
259	Bee	1	0	1	0	0	0	0	0
260	Bee	1	0	0	0	0	1	0	0
261	Bee	1	0	0	0	0	0	1	0
262	Bee	1	0	0	0	0	0	0	1
263	Bee	1	0	1	0	0	0	0	0
264	Bee	1	0	0	0	0	1	0	0
265	Bee	1	0	0	0	0	0	1	0
266	Bee	1	0	0	0	0	0	0	1
267	Bee	1	0	1	0	0	0	0	0
268	Bee	1	0	0	0	0	1	0	0
269	Bee	1	0	0	0	0	0	1	0
270	Bee	1	0	0	0	0	0	0	1

Appendix 2

Idealized Trait Combinations		Flower Shape							Size	
Number	Pollination Syndrome	Trap	Open	Bell	Brush	Gullet	Flag	Tube	Medium/ Small	Mechanically Strong
271	Bee	0	0	0	0	0	0	1	1	1
272	Bee	0	0	0	0	0	0	1	1	1
273	Bee	0	0	0	0	0	0	1	1	1
274	Bee	0	0	0	0	0	0	1	1	1
275	Bee	0	0	0	0	0	0	1	1	1
276	Bee	0	0	0	0	0	0	1	1	1
277	Bee	0	0	0	0	0	0	1	1	1
278	Bee	0	0	0	0	0	0	1	1	1
279	Moth	0	0	0	1	0	0	0	1	0
280	Moth	0	0	0	1	0	0	0	1	0
281	Moth	0	0	0	1	0	0	0	1	0
282	Moth	0	0	0	1	0	0	0	1	0
283	Moth	0	0	0	0	1	0	0	1	0
284	Moth	0	0	0	0	1	0	0	1	0
285	Moth	0	0	0	0	1	0	0	1	0
286	Moth	0	0	0	0	1	0	0	1	0
287	Moth	0	0	0	0	0	0	1	1	0
288	Moth	0	0	0	0	0	0	1	1	0
289	Moth	0	0	0	0	0	0	1	1	0
290	Moth	0	0	0	0	0	0	1	1	0
291	Hawkmoth	0	0	0	1	0	0	1	0	0
292	Hawkmoth	0	0	0	1	0	0	1	0	0
293	Hawkmoth	0	0	0	1	0	0	1	0	0
294	Hawkmoth	0	0	0	1	0	0	1	0	0
295	Hawkmoth	0	0	0	1	0	0	1	0	0
296	Hawkmoth	0	0	0	1	0	0	1	0	0
297	Hawkmoth	0	0	0	1	0	0	1	0	0
298	Hawkmoth	0	0	0	1	0	0	1	0	0
299	Hawkmoth	0	0	0	1	0	0	1	0	0
300	Hawkmoth	0	0	0	1	0	0	1	0	0
301	Hawkmoth	0	0	0	1	0	0	1	0	0
302	Hawkmoth	0	0	0	1	0	0	1	0	0
303	Hawkmoth	0	0	0	1	0	0	1	1	0
304	Hawkmoth	0	0	0	1	0	0	1	1	0
305	Hawkmoth	0	0	0	1	0	0	1	1	0
306	Hawkmoth	0	0	0	1	0	0	1	1	0
307	Hawkmoth	0	0	0	1	0	0	1	1	0
308	Hawkmoth	0	0	0	1	0	0	1	1	0
309	Hawkmoth	0	0	0	1	0	0	1	1	0

Appendix 2

Idealized Trait Combinations		Symmetry	Anthers		Flower Orientation		
Number	Pollination Syndrome	Zygomorphic	Stiff	Exposed	Pendant	Upright	Horizontal
271	Bee	1	0	0	0	0	1
272	Bee	1	0	0	0	0	1
273	Bee	1	0	0	0	0	1
274	Bee	1	0	0	0	0	1
275	Bee	1	0	0	0	0	1
276	Bee	1	0	0	0	0	1
277	Bee	1	0	0	0	0	1
278	Bee	1	0	0	0	0	1
279	Moth	0	0	0	1	0	0
280	Moth	0	0	0	1	0	0
281	Moth	0	0	0	0	0	1
282	Moth	0	0	0	0	0	1
283	Moth	0	0	0	1	0	0
284	Moth	0	0	0	1	0	0
285	Moth	0	0	0	0	0	1
286	Moth	0	0	0	0	0	1
287	Moth	0	0	0	1	0	0
288	Moth	0	0	0	1	0	0
289	Moth	0	0	0	0	0	1
290	Moth	0	0	0	0	0	1
291	Hawkmoth	0	0	0	1	0	0
292	Hawkmoth	0	0	0	1	0	0
293	Hawkmoth	0	0	0	1	0	0
294	Hawkmoth	0	0	0	1	0	0
295	Hawkmoth	0	0	0	1	0	0
296	Hawkmoth	0	0	0	1	0	0
297	Hawkmoth	0	0	0	0	0	1
298	Hawkmoth	0	0	0	0	0	1
299	Hawkmoth	0	0	0	0	0	1
300	Hawkmoth	0	0	0	0	0	1
301	Hawkmoth	0	0	0	0	0	1
302	Hawkmoth	0	0	0	0	0	1
303	Hawkmoth	0	0	0	1	0	0
304	Hawkmoth	0	0	0	1	0	0
305	Hawkmoth	0	0	0	1	0	0
306	Hawkmoth	0	0	0	1	0	0
307	Hawkmoth	0	0	0	1	0	0
308	Hawkmoth	0	0	0	1	0	0
309	Hawkmoth	0	0	0	0	0	1

Appendix 2

Idealized Trait Combinations		Tube Morphology				Time of Opening	Nectar		Nectar Volume	
Number	Pollination Syndrome	Narrow	Wide	Short	Long	Day	Guides	Present	Abundant	Moderate
271	Bee	1	0	1	0	1	1	1	0	1
272	Bee	1	0	1	0	1	1	1	0	1
273	Bee	1	0	1	0	1	1	1	0	1
274	Bee	1	0	1	0	1	1	1	0	1
275	Bee	0	1	1	0	1	1	1	0	1
276	Bee	0	1	1	0	1	1	1	0	1
277	Bee	0	1	1	0	1	1	1	0	1
278	Bee	0	1	1	0	1	1	1	0	1
279	Moth	1	0	0	1	0	0	1	0	1
280	Moth	1	0	0	1	0	0	1	0	1
281	Moth	1	0	0	1	0	0	1	0	1
282	Moth	1	0	0	1	0	0	1	0	1
283	Moth	1	0	0	1	0	0	1	0	1
284	Moth	1	0	0	1	0	0	1	0	1
285	Moth	1	0	0	1	0	0	1	0	1
286	Moth	1	0	0	1	0	0	1	0	1
287	Moth	1	0	0	1	0	0	1	0	1
288	Moth	1	0	0	1	0	0	1	0	1
289	Moth	1	0	0	1	0	0	1	0	1
290	Moth	1	0	0	1	0	0	1	0	1
291	Hawkmoth	1	0	0	1	0	0	1	1	0
292	Hawkmoth	1	0	0	1	0	0	1	0	1
293	Hawkmoth	1	0	0	1	0	0	1	1	0
294	Hawkmoth	1	0	0	1	0	0	1	0	1
295	Hawkmoth	1	0	0	1	0	0	1	1	0
296	Hawkmoth	1	0	0	1	0	0	1	0	1
297	Hawkmoth	1	0	0	1	0	0	1	1	0
298	Hawkmoth	1	0	0	1	0	0	1	0	1
299	Hawkmoth	1	0	0	1	0	0	1	1	0
300	Hawkmoth	1	0	0	1	0	0	1	0	1
301	Hawkmoth	1	0	0	1	0	0	1	1	0
302	Hawkmoth	1	0	0	1	0	0	1	0	1
303	Hawkmoth	1	0	0	1	0	0	1	1	0
304	Hawkmoth	1	0	0	1	0	0	1	0	1
305	Hawkmoth	1	0	0	1	0	0	1	1	0
306	Hawkmoth	1	0	0	1	0	0	1	0	1
307	Hawkmoth	1	0	0	1	0	0	1	1	0
308	Hawkmoth	1	0	0	1	0	0	1	0	1
309	Hawkmoth	1	0	0	1	0	0	1	1	0

Appendix 2

Idealized Trait Combinations		Odor Strength		Scent Type					
Number	Pollination Syndrome	Strong	None	Sweet	Fruity	Fresh	Musky	Sour	Decaying
271	Bee	0	0	0	0	1	0	0	0
272	Bee	0	0	0	0	1	0	0	0
273	Bee	0	0	0	0	1	0	0	0
274	Bee	0	0	0	0	1	0	0	0
275	Bee	0	0	0	0	1	0	0	0
276	Bee	0	0	0	0	1	0	0	0
277	Bee	0	0	0	0	1	0	0	0
278	Bee	0	0	0	0	1	0	0	0
279	Moth	1	0	1	0	0	0	0	0
280	Moth	1	0	1	0	0	0	0	0
281	Moth	1	0	1	0	0	0	0	0
282	Moth	1	0	1	0	0	0	0	0
283	Moth	1	0	1	0	0	0	0	0
284	Moth	1	0	1	0	0	0	0	0
285	Moth	1	0	1	0	0	0	0	0
286	Moth	1	0	1	0	0	0	0	0
287	Moth	1	0	1	0	0	0	0	0
288	Moth	1	0	1	0	0	0	0	0
289	Moth	1	0	1	0	0	0	0	0
290	Moth	1	0	1	0	0	0	0	0
291	Hawkmoth	1	0	1	0	0	0	0	0
292	Hawkmoth	1	0	1	0	0	0	0	0
293	Hawkmoth	1	0	1	0	0	0	0	0
294	Hawkmoth	1	0	1	0	0	0	0	0
295	Hawkmoth	1	0	1	0	0	0	0	0
296	Hawkmoth	1	0	1	0	0	0	0	0
297	Hawkmoth	1	0	1	0	0	0	0	0
298	Hawkmoth	1	0	1	0	0	0	0	0
299	Hawkmoth	1	0	1	0	0	0	0	0
300	Hawkmoth	1	0	1	0	0	0	0	0
301	Hawkmoth	1	0	1	0	0	0	0	0
302	Hawkmoth	1	0	1	0	0	0	0	0
303	Hawkmoth	1	0	1	0	0	0	0	0
304	Hawkmoth	1	0	1	0	0	0	0	0
305	Hawkmoth	1	0	1	0	0	0	0	0
306	Hawkmoth	1	0	1	0	0	0	0	0
307	Hawkmoth	1	0	1	0	0	0	0	0
308	Hawkmoth	1	0	1	0	0	0	0	0
309	Hawkmoth	1	0	1	0	0	0	0	0

Appendix 2

Idealized Trait Combinations		Color Brightness	Color						
Number	Pollination Syndrome	Vivid	Brown	White	Red	Green	Yellow	Blue	Purple
271	Bee	1	0	1	0	0	0	0	0
272	Bee	1	0	0	0	0	1	0	0
273	Bee	1	0	0	0	0	0	1	0
274	Bee	1	0	0	0	0	0	0	1
275	Bee	1	0	1	0	0	0	0	0
276	Bee	1	0	0	0	0	1	0	0
277	Bee	1	0	0	0	0	0	1	0
278	Bee	1	0	0	0	0	0	0	1
279	Moth	0	0	1	0	0	0	0	0
280	Moth	0	0	0	1	0	0	0	0
281	Moth	0	0	1	0	0	0	0	0
282	Moth	0	0	0	1	0	0	0	0
283	Moth	0	0	1	0	0	0	0	0
284	Moth	0	0	0	1	0	0	0	0
285	Moth	0	0	1	0	0	0	0	0
286	Moth	0	0	0	1	0	0	0	0
287	Moth	0	0	1	0	0	0	0	0
288	Moth	0	0	0	1	0	0	0	0
289	Moth	0	0	1	0	0	0	0	0
290	Moth	0	0	0	1	0	0	0	0
291	Hawkmoth	0	0	1	0	0	0	0	0
292	Hawkmoth	0	0	1	0	0	0	0	0
293	Hawkmoth	0	0	0	1	0	0	0	0
294	Hawkmoth	0	0	0	1	0	0	0	0
295	Hawkmoth	0	0	0	0	0	1	0	0
296	Hawkmoth	0	0	0	0	0	1	0	0
297	Hawkmoth	0	0	1	0	0	0	0	0
298	Hawkmoth	0	0	1	0	0	0	0	0
299	Hawkmoth	0	0	0	1	0	0	0	0
300	Hawkmoth	0	0	0	1	0	0	0	0
301	Hawkmoth	0	0	0	0	0	1	0	0
302	Hawkmoth	0	0	0	0	0	1	0	0
303	Hawkmoth	0	0	1	0	0	0	0	0
304	Hawkmoth	0	0	1	0	0	0	0	0
305	Hawkmoth	0	0	0	1	0	0	0	0
306	Hawkmoth	0	0	0	1	0	0	0	0
307	Hawkmoth	0	0	0	0	0	1	0	0
308	Hawkmoth	0	0	0	0	0	1	0	0
309	Hawkmoth	0	0	1	0	0	0	0	0

Appendix 2

Idealized Trait Combinations		Flower Shape							Size	
Number	Pollination Syndrome	Trap	Open	Bell	Brush	Gullet	Flag	Tube	Medium/ Small	Mechanically Strong
310	Hawkmoth	0	0	0	1	0	0	1	1	0
311	Hawkmoth	0	0	0	1	0	0	1	1	0
312	Hawkmoth	0	0	0	1	0	0	1	1	0
313	Hawkmoth	0	0	0	1	0	0	1	1	0
314	Hawkmoth	0	0	0	1	0	0	1	1	0
315	Hawkmoth	0	0	0	0	1	0	1	0	0
316	Hawkmoth	0	0	0	0	1	0	1	0	0
317	Hawkmoth	0	0	0	0	1	0	1	0	0
318	Hawkmoth	0	0	0	0	1	0	1	0	0
319	Hawkmoth	0	0	0	0	1	0	1	0	0
320	Hawkmoth	0	0	0	0	1	0	1	0	0
321	Hawkmoth	0	0	0	0	1	0	1	0	0
322	Hawkmoth	0	0	0	0	1	0	1	0	0
323	Hawkmoth	0	0	0	0	1	0	1	0	0
324	Hawkmoth	0	0	0	0	1	0	1	0	0
325	Hawkmoth	0	0	0	0	1	0	1	0	0
326	Hawkmoth	0	0	0	0	1	0	1	0	0
327	Hawkmoth	0	0	0	0	1	0	1	1	0
328	Hawkmoth	0	0	0	0	1	0	1	1	0
329	Hawkmoth	0	0	0	0	1	0	1	1	0
330	Hawkmoth	0	0	0	0	1	0	1	1	0
331	Hawkmoth	0	0	0	0	1	0	1	1	0
332	Hawkmoth	0	0	0	0	1	0	1	1	0
333	Hawkmoth	0	0	0	0	1	0	1	1	0
334	Hawkmoth	0	0	0	0	1	0	1	1	0
335	Hawkmoth	0	0	0	0	1	0	1	1	0
336	Hawkmoth	0	0	0	0	1	0	1	1	0
337	Hawkmoth	0	0	0	0	1	0	1	1	0
338	Hawkmoth	0	0	0	0	1	0	1	1	0
339	Bird	0	0	1	0	0	0	0	0	1
340	Bird	0	0	1	0	0	0	0	0	1
341	Bird	0	0	1	0	0	0	0	0	1
342	Bird	0	0	1	0	0	0	0	0	1
343	Bird	0	0	1	0	0	0	0	0	1
344	Bird	0	0	1	0	0	0	0	0	1
345	Bird	0	0	1	0	0	0	0	0	1
346	Bird	0	0	1	0	0	0	0	0	1
347	Bird	0	0	1	0	0	0	0	0	1
348	Bird	0	0	1	0	0	0	0	0	1
349	Bird	0	0	1	0	0	0	0	0	1

Appendix 2

Idealized Trait Combinations		Symmetry	Anthers		Flower Orientation		
Number	Pollination Syndrome	Zygomorphic	Stiff	Exposed	Pendant	Upright	Horizontal
310	Hawkmoth	0	0	0	0	0	1
311	Hawkmoth	0	0	0	0	0	1
312	Hawkmoth	0	0	0	0	0	1
313	Hawkmoth	0	0	0	0	0	1
314	Hawkmoth	0	0	0	0	0	1
315	Hawkmoth	0	0	0	1	0	0
316	Hawkmoth	0	0	0	1	0	0
317	Hawkmoth	0	0	0	1	0	0
318	Hawkmoth	0	0	0	1	0	0
319	Hawkmoth	0	0	0	1	0	0
320	Hawkmoth	0	0	0	1	0	0
321	Hawkmoth	0	0	0	0	0	1
322	Hawkmoth	0	0	0	0	0	1
323	Hawkmoth	0	0	0	0	0	1
324	Hawkmoth	0	0	0	0	0	1
325	Hawkmoth	0	0	0	0	0	1
326	Hawkmoth	0	0	0	0	0	1
327	Hawkmoth	0	0	0	1	0	0
328	Hawkmoth	0	0	0	1	0	0
329	Hawkmoth	0	0	0	1	0	0
330	Hawkmoth	0	0	0	1	0	0
331	Hawkmoth	0	0	0	1	0	0
332	Hawkmoth	0	0	0	1	0	0
333	Hawkmoth	0	0	0	0	0	1
334	Hawkmoth	0	0	0	0	0	1
335	Hawkmoth	0	0	0	0	0	1
336	Hawkmoth	0	0	0	0	0	1
337	Hawkmoth	0	0	0	0	0	1
338	Hawkmoth	0	0	0	0	0	1
339	Bird	0	1	1	1	0	0
340	Bird	0	1	1	1	0	0
341	Bird	0	1	1	1	0	0
342	Bird	0	1	1	1	0	0
343	Bird	0	1	1	1	0	0
344	Bird	0	1	1	1	0	0
345	Bird	0	1	1	0	1	0
346	Bird	0	1	1	0	1	0
347	Bird	0	1	1	0	1	0
348	Bird	0	1	1	0	1	0
349	Bird	0	1	1	0	1	0

Appendix 2

Idealized Trait Combinations		Tube Morphology				Time of Opening	Nectar		Nectar Volume	
Number	Pollination Syndrome	Narrow	Wide	Short	Long	Day	Guides	Present	Abundant	Moderate
310	Hawkmoth	1	0	0	1	0	0	1	0	1
311	Hawkmoth	1	0	0	1	0	0	1	1	0
312	Hawkmoth	1	0	0	1	0	0	1	0	1
313	Hawkmoth	1	0	0	1	0	0	1	1	0
314	Hawkmoth	1	0	0	1	0	0	1	0	1
315	Hawkmoth	1	0	0	1	0	0	1	1	0
316	Hawkmoth	1	0	0	1	0	0	1	0	1
317	Hawkmoth	1	0	0	1	0	0	1	1	0
318	Hawkmoth	1	0	0	1	0	0	1	0	1
319	Hawkmoth	1	0	0	1	0	0	1	1	0
320	Hawkmoth	1	0	0	1	0	0	1	0	1
321	Hawkmoth	1	0	0	1	0	0	1	1	0
322	Hawkmoth	1	0	0	1	0	0	1	0	1
323	Hawkmoth	1	0	0	1	0	0	1	1	0
324	Hawkmoth	1	0	0	1	0	0	1	0	1
325	Hawkmoth	1	0	0	1	0	0	1	1	0
326	Hawkmoth	1	0	0	1	0	0	1	0	1
327	Hawkmoth	1	0	0	1	0	0	1	1	0
328	Hawkmoth	1	0	0	1	0	0	1	0	1
329	Hawkmoth	1	0	0	1	0	0	1	1	0
330	Hawkmoth	1	0	0	1	0	0	1	0	1
331	Hawkmoth	1	0	0	1	0	0	1	1	0
332	Hawkmoth	1	0	0	1	0	0	1	0	1
333	Hawkmoth	1	0	0	1	0	0	1	1	0
334	Hawkmoth	1	0	0	1	0	0	1	0	1
335	Hawkmoth	1	0	0	1	0	0	1	1	0
336	Hawkmoth	1	0	0	1	0	0	1	0	1
337	Hawkmoth	1	0	0	1	0	0	1	1	0
338	Hawkmoth	1	0	0	1	0	0	1	0	1
339	Bird	1	0	1	0	1	1	1	1	0
340	Bird	1	0	1	0	1	1	1	1	0
341	Bird	1	0	1	0	1	1	1	1	0
342	Bird	1	0	0	1	1	1	1	1	0
343	Bird	1	0	0	1	1	1	1	1	0
344	Bird	1	0	0	1	1	1	1	1	0
345	Bird	1	0	1	0	1	1	1	1	0
346	Bird	1	0	1	0	1	1	1	1	0
347	Bird	1	0	1	0	1	1	1	1	0
348	Bird	1	0	0	1	1	1	1	1	0
349	Bird	1	0	0	1	1	1	1	1	0

Appendix 2

Idealized Trait Combinations		Odor Strength		Scent Type					
Number	Pollination Syndrome	Strong	None	Sweet	Fruity	Fresh	Musky	Sour	Decaying
310	Hawkmoth	1	0	1	0	0	0	0	0
311	Hawkmoth	1	0	1	0	0	0	0	0
312	Hawkmoth	1	0	1	0	0	0	0	0
313	Hawkmoth	1	0	1	0	0	0	0	0
314	Hawkmoth	1	0	1	0	0	0	0	0
315	Hawkmoth	1	0	1	0	0	0	0	0
316	Hawkmoth	1	0	1	0	0	0	0	0
317	Hawkmoth	1	0	1	0	0	0	0	0
318	Hawkmoth	1	0	1	0	0	0	0	0
319	Hawkmoth	1	0	1	0	0	0	0	0
320	Hawkmoth	1	0	1	0	0	0	0	0
321	Hawkmoth	1	0	1	0	0	0	0	0
322	Hawkmoth	1	0	1	0	0	0	0	0
323	Hawkmoth	1	0	1	0	0	0	0	0
324	Hawkmoth	1	0	1	0	0	0	0	0
325	Hawkmoth	1	0	1	0	0	0	0	0
326	Hawkmoth	1	0	1	0	0	0	0	0
327	Hawkmoth	1	0	1	0	0	0	0	0
328	Hawkmoth	1	0	1	0	0	0	0	0
329	Hawkmoth	1	0	1	0	0	0	0	0
330	Hawkmoth	1	0	1	0	0	0	0	0
331	Hawkmoth	1	0	1	0	0	0	0	0
332	Hawkmoth	1	0	1	0	0	0	0	0
333	Hawkmoth	1	0	1	0	0	0	0	0
334	Hawkmoth	1	0	1	0	0	0	0	0
335	Hawkmoth	1	0	1	0	0	0	0	0
336	Hawkmoth	1	0	1	0	0	0	0	0
337	Hawkmoth	1	0	1	0	0	0	0	0
338	Hawkmoth	1	0	1	0	0	0	0	0
339	Bird	0	1	0	0	0	0	0	0
340	Bird	0	1	0	0	0	0	0	0
341	Bird	0	1	0	0	0	0	0	0
342	Bird	0	1	0	0	0	0	0	0
343	Bird	0	1	0	0	0	0	0	0
344	Bird	0	1	0	0	0	0	0	0
345	Bird	0	1	0	0	0	0	0	0
346	Bird	0	1	0	0	0	0	0	0
347	Bird	0	1	0	0	0	0	0	0
348	Bird	0	1	0	0	0	0	0	0
349	Bird	0	1	0	0	0	0	0	0

Appendix 2

Idealized Trait Combinations		Color Brightness	Color						
Number	Pollination Syndrome	Vivid	Brown	White	Red	Green	Yellow	Blue	Purple
310	Hawkmoth	0	0	1	0	0	0	0	0
311	Hawkmoth	0	0	0	1	0	0	0	0
312	Hawkmoth	0	0	0	1	0	0	0	0
313	Hawkmoth	0	0	0	0	0	1	0	0
314	Hawkmoth	0	0	0	0	0	1	0	0
315	Hawkmoth	0	0	1	0	0	0	0	0
316	Hawkmoth	0	0	1	0	0	0	0	0
317	Hawkmoth	0	0	0	1	0	0	0	0
318	Hawkmoth	0	0	0	1	0	0	0	0
319	Hawkmoth	0	0	0	0	0	1	0	0
320	Hawkmoth	0	0	0	0	0	1	0	0
321	Hawkmoth	0	0	1	0	0	0	0	0
322	Hawkmoth	0	0	1	0	0	0	0	0
323	Hawkmoth	0	0	0	1	0	0	0	0
324	Hawkmoth	0	0	0	1	0	0	0	0
325	Hawkmoth	0	0	0	0	0	1	0	0
326	Hawkmoth	0	0	0	0	0	1	0	0
327	Hawkmoth	0	0	1	0	0	0	0	0
328	Hawkmoth	0	0	1	0	0	0	0	0
329	Hawkmoth	0	0	0	1	0	0	0	0
330	Hawkmoth	0	0	0	1	0	0	0	0
331	Hawkmoth	0	0	0	0	0	1	0	0
332	Hawkmoth	0	0	0	0	0	1	0	0
333	Hawkmoth	0	0	1	0	0	0	0	0
334	Hawkmoth	0	0	1	0	0	0	0	0
335	Hawkmoth	0	0	0	1	0	0	0	0
336	Hawkmoth	0	0	0	1	0	0	0	0
337	Hawkmoth	0	0	0	0	0	1	0	0
338	Hawkmoth	0	0	0	0	0	1	0	0
339	Bird	1	0	0	1	0	0	0	0
340	Bird	1	0	0	0	1	0	0	0
341	Bird	1	0	0	0	0	0	1	0
342	Bird	1	0	0	1	0	0	0	0
343	Bird	1	0	0	0	1	0	0	0
344	Bird	1	0	0	0	0	0	1	0
345	Bird	1	0	0	1	0	0	0	0
346	Bird	1	0	0	0	1	0	0	0
347	Bird	1	0	0	0	0	0	1	0
348	Bird	1	0	0	1	0	0	0	0
349	Bird	1	0	0	0	1	0	0	0

Appendix 2

Idealized Trait Combinations		Flower Shape							Size	
Number	Pollination Syndrome	Trap	Open	Bell	Brush	Gullet	Flag	Tube	Medium/ Small	Mechanically Strong
350	Bird	0	0	1	0	0	0	0	0	1
351	Bird	0	0	1	0	0	0	0	0	1
352	Bird	0	0	1	0	0	0	0	0	1
353	Bird	0	0	1	0	0	0	0	0	1
354	Bird	0	0	1	0	0	0	0	0	1
355	Bird	0	0	1	0	0	0	0	0	1
356	Bird	0	0	1	0	0	0	0	0	1
357	Bird	0	0	1	0	0	0	0	1	1
358	Bird	0	0	1	0	0	0	0	1	1
359	Bird	0	0	1	0	0	0	0	1	1
360	Bird	0	0	1	0	0	0	0	1	1
361	Bird	0	0	1	0	0	0	0	1	1
362	Bird	0	0	1	0	0	0	0	1	1
363	Bird	0	0	1	0	0	0	0	1	1
364	Bird	0	0	1	0	0	0	0	1	1
365	Bird	0	0	1	0	0	0	0	1	1
366	Bird	0	0	1	0	0	0	0	1	1
367	Bird	0	0	1	0	0	0	0	1	1
368	Bird	0	0	1	0	0	0	0	1	1
369	Bird	0	0	1	0	0	0	0	1	1
370	Bird	0	0	1	0	0	0	0	1	1
371	Bird	0	0	1	0	0	0	0	1	1
372	Bird	0	0	1	0	0	0	0	1	1
373	Bird	0	0	1	0	0	0	0	1	1
374	Bird	0	0	1	0	0	0	0	1	1
375	Bird	0	0	0	1	0	0	0	0	1
376	Bird	0	0	0	1	0	0	0	0	1
377	Bird	0	0	0	1	0	0	0	0	1
378	Bird	0	0	0	1	0	0	0	0	1
379	Bird	0	0	0	1	0	0	0	0	1
380	Bird	0	0	0	1	0	0	0	0	1
381	Bird	0	0	0	1	0	0	0	0	1
382	Bird	0	0	0	1	0	0	0	0	1
383	Bird	0	0	0	1	0	0	0	0	1
384	Bird	0	0	0	1	0	0	0	0	1
385	Bird	0	0	0	1	0	0	0	0	1
386	Bird	0	0	0	1	0	0	0	0	1
387	Bird	0	0	0	1	0	0	0	0	1
388	Bird	0	0	0	1	0	0	0	0	1

Appendix 2

Idealized Trait Combinations		Symmetry	Anthers		Flower Orientation		
Number	Pollination Syndrome	Zygomorphic	Stiff	Exposed	Pendant	Upright	Horizontal
350	Bird	0	1	1	0	1	0
351	Bird	0	1	1	0	0	1
352	Bird	0	1	1	0	0	1
353	Bird	0	1	1	0	0	1
354	Bird	0	1	1	0	0	1
355	Bird	0	1	1	0	0	1
356	Bird	0	1	1	0	0	1
357	Bird	0	1	1	1	0	0
358	Bird	0	1	1	1	0	0
359	Bird	0	1	1	1	0	0
360	Bird	0	1	1	1	0	0
361	Bird	0	1	1	1	0	0
362	Bird	0	1	1	1	0	0
363	Bird	0	1	1	0	1	0
364	Bird	0	1	1	0	1	0
365	Bird	0	1	1	0	1	0
366	Bird	0	1	1	0	1	0
367	Bird	0	1	1	0	1	0
368	Bird	0	1	1	0	1	0
369	Bird	0	1	1	0	0	1
370	Bird	0	1	1	0	0	1
371	Bird	0	1	1	0	0	1
372	Bird	0	1	1	0	0	1
373	Bird	0	1	1	0	0	1
374	Bird	0	1	1	0	0	1
375	Bird	0	1	1	1	0	0
376	Bird	0	1	1	1	0	0
377	Bird	0	1	1	1	0	0
378	Bird	0	1	1	1	0	0
379	Bird	0	1	1	1	0	0
380	Bird	0	1	1	1	0	0
381	Bird	0	1	1	0	1	0
382	Bird	0	1	1	0	1	0
383	Bird	0	1	1	0	1	0
384	Bird	0	1	1	0	1	0
385	Bird	0	1	1	0	1	0
386	Bird	0	1	1	0	1	0
387	Bird	0	1	1	0	0	1
388	Bird	0	1	1	0	0	1

Appendix 2

Idealized Trait Combinations		Tube Morphology				Time of Opening	Nectar		Nectar Volume	
Number	Pollination Syndrome	Narrow	Wide	Short	Long	Day	Guides	Present	Abundant	Moderate
350	Bird	1	0	0	1	1	1	1	1	0
351	Bird	1	0	1	0	1	1	1	1	0
352	Bird	1	0	1	0	1	1	1	1	0
353	Bird	1	0	1	0	1	1	1	1	0
354	Bird	1	0	0	1	1	1	1	1	0
355	Bird	1	0	0	1	1	1	1	1	0
356	Bird	1	0	0	1	1	1	1	1	0
357	Bird	1	0	1	0	1	1	1	1	0
358	Bird	1	0	1	0	1	1	1	1	0
359	Bird	1	0	1	0	1	1	1	1	0
360	Bird	1	0	0	1	1	1	1	1	0
361	Bird	1	0	0	1	1	1	1	1	0
362	Bird	1	0	0	1	1	1	1	1	0
363	Bird	1	0	1	0	1	1	1	1	0
364	Bird	1	0	1	0	1	1	1	1	0
365	Bird	1	0	1	0	1	1	1	1	0
366	Bird	1	0	0	1	1	1	1	1	0
367	Bird	1	0	0	1	1	1	1	1	0
368	Bird	1	0	0	1	1	1	1	1	0
369	Bird	1	0	1	0	1	1	1	1	0
370	Bird	1	0	1	0	1	1	1	1	0
371	Bird	1	0	1	0	1	1	1	1	0
372	Bird	1	0	0	1	1	1	1	1	0
373	Bird	1	0	0	1	1	1	1	1	0
374	Bird	1	0	0	1	1	1	1	1	0
375	Bird	1	0	1	0	1	1	1	1	0
376	Bird	1	0	1	0	1	1	1	1	0
377	Bird	1	0	1	0	1	1	1	1	0
378	Bird	1	0	0	1	1	1	1	1	0
379	Bird	1	0	0	1	1	1	1	1	0
380	Bird	1	0	0	1	1	1	1	1	0
381	Bird	1	0	1	0	1	1	1	1	0
382	Bird	1	0	1	0	1	1	1	1	0
383	Bird	1	0	1	0	1	1	1	1	0
384	Bird	1	0	0	1	1	1	1	1	0
385	Bird	1	0	0	1	1	1	1	1	0
386	Bird	1	0	0	1	1	1	1	1	0
387	Bird	1	0	1	0	1	1	1	1	0
388	Bird	1	0	1	0	1	1	1	1	0

Appendix 2

Idealized Trait Combinations		Odor Strength		Scent Type					
Number	Pollination Syndrome	Strong	None	Sweet	Fruity	Fresh	Musky	Sour	Decaying
350	Bird	0	1	0	0	0	0	0	0
351	Bird	0	1	0	0	0	0	0	0
352	Bird	0	1	0	0	0	0	0	0
353	Bird	0	1	0	0	0	0	0	0
354	Bird	0	1	0	0	0	0	0	0
355	Bird	0	1	0	0	0	0	0	0
356	Bird	0	1	0	0	0	0	0	0
357	Bird	0	1	0	0	0	0	0	0
358	Bird	0	1	0	0	0	0	0	0
359	Bird	0	1	0	0	0	0	0	0
360	Bird	0	1	0	0	0	0	0	0
361	Bird	0	1	0	0	0	0	0	0
362	Bird	0	1	0	0	0	0	0	0
363	Bird	0	1	0	0	0	0	0	0
364	Bird	0	1	0	0	0	0	0	0
365	Bird	0	1	0	0	0	0	0	0
366	Bird	0	1	0	0	0	0	0	0
367	Bird	0	1	0	0	0	0	0	0
368	Bird	0	1	0	0	0	0	0	0
369	Bird	0	1	0	0	0	0	0	0
370	Bird	0	1	0	0	0	0	0	0
371	Bird	0	1	0	0	0	0	0	0
372	Bird	0	1	0	0	0	0	0	0
373	Bird	0	1	0	0	0	0	0	0
374	Bird	0	1	0	0	0	0	0	0
375	Bird	0	1	0	0	0	0	0	0
376	Bird	0	1	0	0	0	0	0	0
377	Bird	0	1	0	0	0	0	0	0
378	Bird	0	1	0	0	0	0	0	0
379	Bird	0	1	0	0	0	0	0	0
380	Bird	0	1	0	0	0	0	0	0
381	Bird	0	1	0	0	0	0	0	0
382	Bird	0	1	0	0	0	0	0	0
383	Bird	0	1	0	0	0	0	0	0
384	Bird	0	1	0	0	0	0	0	0
385	Bird	0	1	0	0	0	0	0	0
386	Bird	0	1	0	0	0	0	0	0
387	Bird	0	1	0	0	0	0	0	0
388	Bird	0	1	0	0	0	0	0	0

Appendix 2

Idealized Trait Combinations		Color Brightness	Color						
Number	Pollination Syndrome	Vivid	Brown	White	Red	Green	Yellow	Blue	Purple
350	Bird	1	0	0	0	0	0	1	0
351	Bird	1	0	0	1	0	0	0	0
352	Bird	1	0	0	0	1	0	0	0
353	Bird	1	0	0	0	0	0	1	0
354	Bird	1	0	0	1	0	0	0	0
355	Bird	1	0	0	0	1	0	0	0
356	Bird	1	0	0	0	0	0	1	0
357	Bird	1	0	0	1	0	0	0	0
358	Bird	1	0	0	0	1	0	0	0
359	Bird	1	0	0	0	0	0	1	0
360	Bird	1	0	0	1	0	0	0	0
361	Bird	1	0	0	0	1	0	0	0
362	Bird	1	0	0	0	0	0	1	0
363	Bird	1	0	0	1	0	0	0	0
364	Bird	1	0	0	0	1	0	0	0
365	Bird	1	0	0	0	0	0	1	0
366	Bird	1	0	0	1	0	0	0	0
367	Bird	1	0	0	0	1	0	0	0
368	Bird	1	0	0	0	0	0	1	0
369	Bird	1	0	0	1	0	0	0	0
370	Bird	1	0	0	0	1	0	0	0
371	Bird	1	0	0	0	0	0	1	0
372	Bird	1	0	0	1	0	0	0	0
373	Bird	1	0	0	0	1	0	0	0
374	Bird	1	0	0	0	0	0	1	0
375	Bird	1	0	0	1	0	0	0	0
376	Bird	1	0	0	0	1	0	0	0
377	Bird	1	0	0	0	0	0	1	0
378	Bird	1	0	0	1	0	0	0	0
379	Bird	1	0	0	0	1	0	0	0
380	Bird	1	0	0	0	0	0	1	0
381	Bird	1	0	0	1	0	0	0	0
382	Bird	1	0	0	0	1	0	0	0
383	Bird	1	0	0	0	0	0	1	0
384	Bird	1	0	0	1	0	0	0	0
385	Bird	1	0	0	0	1	0	0	0
386	Bird	1	0	0	0	0	0	1	0
387	Bird	1	0	0	1	0	0	0	0
388	Bird	1	0	0	0	1	0	0	0

Appendix 2

Idealized Trait Combinations		Flower Shape							Size	
Number	Pollination Syndrome	Trap	Open	Bell	Brush	Gullet	Flag	Tube	Medium/ Small	Mechanically Strong
389	Bird	0	0	0	1	0	0	0	0	1
390	Bird	0	0	0	1	0	0	0	0	1
391	Bird	0	0	0	1	0	0	0	0	1
392	Bird	0	0	0	1	0	0	0	0	1
393	Bird	0	0	0	1	0	0	0	1	1
394	Bird	0	0	0	1	0	0	0	1	1
395	Bird	0	0	0	1	0	0	0	1	1
396	Bird	0	0	0	1	0	0	0	1	1
397	Bird	0	0	0	1	0	0	0	1	1
398	Bird	0	0	0	1	0	0	0	1	1
399	Bird	0	0	0	1	0	0	0	1	1
400	Bird	0	0	0	1	0	0	0	1	1
401	Bird	0	0	0	1	0	0	0	1	1
402	Bird	0	0	0	1	0	0	0	1	1
403	Bird	0	0	0	1	0	0	0	1	1
404	Bird	0	0	0	1	0	0	0	1	1
405	Bird	0	0	0	1	0	0	0	1	1
406	Bird	0	0	0	1	0	0	0	1	1
407	Bird	0	0	0	1	0	0	0	1	1
408	Bird	0	0	0	1	0	0	0	1	1
409	Bird	0	0	0	1	0	0	0	1	1
410	Bird	0	0	0	1	0	0	0	1	1
411	Bird	0	0	0	0	1	0	0	0	1
412	Bird	0	0	0	0	1	0	0	0	1
413	Bird	0	0	0	0	1	0	0	0	1
414	Bird	0	0	0	0	1	0	0	0	1
415	Bird	0	0	0	0	1	0	0	0	1
416	Bird	0	0	0	0	1	0	0	0	1
417	Bird	0	0	0	0	1	0	0	0	1
418	Bird	0	0	0	0	1	0	0	0	1
419	Bird	0	0	0	0	1	0	0	0	1
420	Bird	0	0	0	0	1	0	0	0	1
421	Bird	0	0	0	0	1	0	0	0	1
422	Bird	0	0	0	0	1	0	0	0	1
423	Bird	0	0	0	0	1	0	0	0	1
424	Bird	0	0	0	0	1	0	0	0	1
425	Bird	0	0	0	0	1	0	0	0	1
426	Bird	0	0	0	0	1	0	0	0	1
427	Bird	0	0	0	0	1	0	0	0	1

Appendix 2

Idealized Trait Combinations		Symmetry	Anthers		Flower Orientation		
Number	Pollination Syndrome	Zygomorphic	Stiff	Exposed	Pendant	Upright	Horizontal
389	Bird	0	1	1	0	0	1
390	Bird	0	1	1	0	0	1
391	Bird	0	1	1	0	0	1
392	Bird	0	1	1	0	0	1
393	Bird	0	1	1	1	0	0
394	Bird	0	1	1	1	0	0
395	Bird	0	1	1	1	0	0
396	Bird	0	1	1	1	0	0
397	Bird	0	1	1	1	0	0
398	Bird	0	1	1	1	0	0
399	Bird	0	1	1	0	1	0
400	Bird	0	1	1	0	1	0
401	Bird	0	1	1	0	1	0
402	Bird	0	1	1	0	1	0
403	Bird	0	1	1	0	1	0
404	Bird	0	1	1	0	1	0
405	Bird	0	1	1	0	0	1
406	Bird	0	1	1	0	0	1
407	Bird	0	1	1	0	0	1
408	Bird	0	1	1	0	0	1
409	Bird	0	1	1	0	0	1
410	Bird	0	1	1	0	0	1
411	Bird	0	1	1	1	0	0
412	Bird	0	1	1	1	0	0
413	Bird	0	1	1	1	0	0
414	Bird	0	1	1	1	0	0
415	Bird	0	1	1	1	0	0
416	Bird	0	1	1	1	0	0
417	Bird	0	1	1	0	1	0
418	Bird	0	1	1	0	1	0
419	Bird	0	1	1	0	1	0
420	Bird	0	1	1	0	1	0
421	Bird	0	1	1	0	1	0
422	Bird	0	1	1	0	1	0
423	Bird	0	1	1	0	0	1
424	Bird	0	1	1	0	0	1
425	Bird	0	1	1	0	0	1
426	Bird	0	1	1	0	0	1
427	Bird	0	1	1	0	0	1

Appendix 2

Idealized Trait Combinations		Tube Morphology				Time of Opening	Nectar		Nectar Volume	
Number	Pollination Syndrome	Narrow	Wide	Short	Long	Day	Guides	Present	Abundant	Moderate
389	Bird	1	0	1	0	1	1	1	1	0
390	Bird	1	0	0	1	1	1	1	1	0
391	Bird	1	0	0	1	1	1	1	1	0
392	Bird	1	0	0	1	1	1	1	1	0
393	Bird	1	0	1	0	1	1	1	1	0
394	Bird	1	0	1	0	1	1	1	1	0
395	Bird	1	0	1	0	1	1	1	1	0
396	Bird	1	0	0	1	1	1	1	1	0
397	Bird	1	0	0	1	1	1	1	1	0
398	Bird	1	0	0	1	1	1	1	1	0
399	Bird	1	0	1	0	1	1	1	1	0
400	Bird	1	0	1	0	1	1	1	1	0
401	Bird	1	0	1	0	1	1	1	1	0
402	Bird	1	0	0	1	1	1	1	1	0
403	Bird	1	0	0	1	1	1	1	1	0
404	Bird	1	0	0	1	1	1	1	1	0
405	Bird	1	0	1	0	1	1	1	1	0
406	Bird	1	0	1	0	1	1	1	1	0
407	Bird	1	0	1	0	1	1	1	1	0
408	Bird	1	0	0	1	1	1	1	1	0
409	Bird	1	0	0	1	1	1	1	1	0
410	Bird	1	0	0	1	1	1	1	1	0
411	Bird	1	0	1	0	1	1	1	1	0
412	Bird	1	0	1	0	1	1	1	1	0
413	Bird	1	0	1	0	1	1	1	1	0
414	Bird	1	0	0	1	1	1	1	1	0
415	Bird	1	0	0	1	1	1	1	1	0
416	Bird	1	0	0	1	1	1	1	1	0
417	Bird	1	0	1	0	1	1	1	1	0
418	Bird	1	0	1	0	1	1	1	1	0
419	Bird	1	0	1	0	1	1	1	1	0
420	Bird	1	0	0	1	1	1	1	1	0
421	Bird	1	0	0	1	1	1	1	1	0
422	Bird	1	0	0	1	1	1	1	1	0
423	Bird	1	0	1	0	1	1	1	1	0
424	Bird	1	0	1	0	1	1	1	1	0
425	Bird	1	0	1	0	1	1	1	1	0
426	Bird	1	0	0	1	1	1	1	1	0
427	Bird	1	0	0	1	1	1	1	1	0

Appendix 2

Idealized Trait Combinations		Odor Strength		Scent Type					
Number	Pollination Syndrome	Strong	None	Sweet	Fruity	Fresh	Musky	Sour	Decaying
389	Bird	0	1	0	0	0	0	0	0
390	Bird	0	1	0	0	0	0	0	0
391	Bird	0	1	0	0	0	0	0	0
392	Bird	0	1	0	0	0	0	0	0
393	Bird	0	1	0	0	0	0	0	0
394	Bird	0	1	0	0	0	0	0	0
395	Bird	0	1	0	0	0	0	0	0
396	Bird	0	1	0	0	0	0	0	0
397	Bird	0	1	0	0	0	0	0	0
398	Bird	0	1	0	0	0	0	0	0
399	Bird	0	1	0	0	0	0	0	0
400	Bird	0	1	0	0	0	0	0	0
401	Bird	0	1	0	0	0	0	0	0
402	Bird	0	1	0	0	0	0	0	0
403	Bird	0	1	0	0	0	0	0	0
404	Bird	0	1	0	0	0	0	0	0
405	Bird	0	1	0	0	0	0	0	0
406	Bird	0	1	0	0	0	0	0	0
407	Bird	0	1	0	0	0	0	0	0
408	Bird	0	1	0	0	0	0	0	0
409	Bird	0	1	0	0	0	0	0	0
410	Bird	0	1	0	0	0	0	0	0
411	Bird	0	1	0	0	0	0	0	0
412	Bird	0	1	0	0	0	0	0	0
413	Bird	0	1	0	0	0	0	0	0
414	Bird	0	1	0	0	0	0	0	0
415	Bird	0	1	0	0	0	0	0	0
416	Bird	0	1	0	0	0	0	0	0
417	Bird	0	1	0	0	0	0	0	0
418	Bird	0	1	0	0	0	0	0	0
419	Bird	0	1	0	0	0	0	0	0
420	Bird	0	1	0	0	0	0	0	0
421	Bird	0	1	0	0	0	0	0	0
422	Bird	0	1	0	0	0	0	0	0
423	Bird	0	1	0	0	0	0	0	0
424	Bird	0	1	0	0	0	0	0	0
425	Bird	0	1	0	0	0	0	0	0
426	Bird	0	1	0	0	0	0	0	0
427	Bird	0	1	0	0	0	0	0	0

Appendix 2

Idealized Trait Combinations		Color Brightness	Color						
Number	Pollination Syndrome	Vivid	Brown	White	Red	Green	Yellow	Blue	Purple
389	Bird	1	0	0	0	0	0	1	0
390	Bird	1	0	0	1	0	0	0	0
391	Bird	1	0	0	0	1	0	0	0
392	Bird	1	0	0	0	0	0	1	0
393	Bird	1	0	0	1	0	0	0	0
394	Bird	1	0	0	0	1	0	0	0
395	Bird	1	0	0	0	0	0	1	0
396	Bird	1	0	0	1	0	0	0	0
397	Bird	1	0	0	0	1	0	0	0
398	Bird	1	0	0	0	0	0	1	0
399	Bird	1	0	0	1	0	0	0	0
400	Bird	1	0	0	0	1	0	0	0
401	Bird	1	0	0	0	0	0	1	0
402	Bird	1	0	0	1	0	0	0	0
403	Bird	1	0	0	0	1	0	0	0
404	Bird	1	0	0	0	0	0	1	0
405	Bird	1	0	0	1	0	0	0	0
406	Bird	1	0	0	0	1	0	0	0
407	Bird	1	0	0	0	0	0	1	0
408	Bird	1	0	0	1	0	0	0	0
409	Bird	1	0	0	0	1	0	0	0
410	Bird	1	0	0	0	0	0	1	0
411	Bird	1	0	0	1	0	0	0	0
412	Bird	1	0	0	0	1	0	0	0
413	Bird	1	0	0	0	0	0	1	0
414	Bird	1	0	0	1	0	0	0	0
415	Bird	1	0	0	0	1	0	0	0
416	Bird	1	0	0	0	0	0	1	0
417	Bird	1	0	0	1	0	0	0	0
418	Bird	1	0	0	0	1	0	0	0
419	Bird	1	0	0	0	0	0	1	0
420	Bird	1	0	0	1	0	0	0	0
421	Bird	1	0	0	0	1	0	0	0
422	Bird	1	0	0	0	0	0	1	0
423	Bird	1	0	0	1	0	0	0	0
424	Bird	1	0	0	0	1	0	0	0
425	Bird	1	0	0	0	0	0	1	0
426	Bird	1	0	0	1	0	0	0	0
427	Bird	1	0	0	0	1	0	0	0

Appendix 2

Idealized Trait Combinations		Flower Shape							Size	
Number	Pollination Syndrome	Trap	Open	Bell	Brush	Gullet	Flag	Tube	Medium/ Small	Mechanically Strong
428	Bird	0	0	0	0	1	0	0	0	1
429	Bird	0	0	0	0	1	0	0	1	1
430	Bird	0	0	0	0	1	0	0	1	1
431	Bird	0	0	0	0	1	0	0	1	1
432	Bird	0	0	0	0	1	0	0	1	1
433	Bird	0	0	0	0	1	0	0	1	1
434	Bird	0	0	0	0	1	0	0	1	1
435	Bird	0	0	0	0	1	0	0	1	1
436	Bird	0	0	0	0	1	0	0	1	1
437	Bird	0	0	0	0	1	0	0	1	1
438	Bird	0	0	0	0	1	0	0	1	1
439	Bird	0	0	0	0	1	0	0	1	1
440	Bird	0	0	0	0	1	0	0	1	1
441	Bird	0	0	0	0	1	0	0	1	1
442	Bird	0	0	0	0	1	0	0	1	1
443	Bird	0	0	0	0	1	0	0	1	1
444	Bird	0	0	0	0	1	0	0	1	1
445	Bird	0	0	0	0	1	0	0	1	1
446	Bird	0	0	0	0	1	0	0	1	1
447	Bird	0	0	0	0	0	1	0	0	1
448	Bird	0	0	0	0	0	1	0	0	1
449	Bird	0	0	0	0	0	1	0	0	1
450	Bird	0	0	0	0	0	1	0	0	1
451	Bird	0	0	0	0	0	1	0	0	1
452	Bird	0	0	0	0	0	1	0	0	1
453	Bird	0	0	0	0	0	1	0	0	1
454	Bird	0	0	0	0	0	1	0	0	1
455	Bird	0	0	0	0	0	1	0	0	1
456	Bird	0	0	0	0	0	1	0	0	1
457	Bird	0	0	0	0	0	1	0	0	1
458	Bird	0	0	0	0	0	1	0	0	1
459	Bird	0	0	0	0	0	1	0	0	1
460	Bird	0	0	0	0	0	1	0	0	1
461	Bird	0	0	0	0	0	1	0	0	1
462	Bird	0	0	0	0	0	1	0	0	1
463	Bird	0	0	0	0	0	1	0	0	1
464	Bird	0	0	0	0	0	1	0	0	1
465	Bird	0	0	0	0	0	1	0	1	1
466	Bird	0	0	0	0	0	1	0	1	1

Appendix 2

Idealized Trait Combinations		Symmetry	Anthers		Flower Orientation		
Number	Pollination Syndrome	Zygomorphic	Stiff	Exposed	Pendant	Upright	Horizontal
428	Bird	0	1	1	0	0	1
429	Bird	0	1	1	1	0	0
430	Bird	0	1	1	1	0	0
431	Bird	0	1	1	1	0	0
432	Bird	0	1	1	1	0	0
433	Bird	0	1	1	1	0	0
434	Bird	0	1	1	1	0	0
435	Bird	0	1	1	0	1	0
436	Bird	0	1	1	0	1	0
437	Bird	0	1	1	0	1	0
438	Bird	0	1	1	0	1	0
439	Bird	0	1	1	0	1	0
440	Bird	0	1	1	0	1	0
441	Bird	0	1	1	0	0	1
442	Bird	0	1	1	0	0	1
443	Bird	0	1	1	0	0	1
444	Bird	0	1	1	0	0	1
445	Bird	0	1	1	0	0	1
446	Bird	0	1	1	0	0	1
447	Bird	0	1	1	1	0	0
448	Bird	0	1	1	1	0	0
449	Bird	0	1	1	1	0	0
450	Bird	0	1	1	1	0	0
451	Bird	0	1	1	1	0	0
452	Bird	0	1	1	1	0	0
453	Bird	0	1	1	0	1	0
454	Bird	0	1	1	0	1	0
455	Bird	0	1	1	0	1	0
456	Bird	0	1	1	0	1	0
457	Bird	0	1	1	0	1	0
458	Bird	0	1	1	0	1	0
459	Bird	0	1	1	0	0	1
460	Bird	0	1	1	0	0	1
461	Bird	0	1	1	0	0	1
462	Bird	0	1	1	0	0	1
463	Bird	0	1	1	0	0	1
464	Bird	0	1	1	0	0	1
465	Bird	0	1	1	1	0	0
466	Bird	0	1	1	1	0	0

Appendix 2

Idealized Trait Combinations		Tube Morphology				Time of Opening	Nectar		Nectar Volume	
Number	Pollination Syndrome	Narrow	Wide	Short	Long	Day	Guides	Present	Abundant	Moderate
428	Bird	1	0	0	1	1	1	1	1	0
429	Bird	1	0	1	0	1	1	1	1	0
430	Bird	1	0	1	0	1	1	1	1	0
431	Bird	1	0	1	0	1	1	1	1	0
432	Bird	1	0	0	1	1	1	1	1	0
433	Bird	1	0	0	1	1	1	1	1	0
434	Bird	1	0	0	1	1	1	1	1	0
435	Bird	1	0	1	0	1	1	1	1	0
436	Bird	1	0	1	0	1	1	1	1	0
437	Bird	1	0	1	0	1	1	1	1	0
438	Bird	1	0	0	1	1	1	1	1	0
439	Bird	1	0	0	1	1	1	1	1	0
440	Bird	1	0	0	1	1	1	1	1	0
441	Bird	1	0	1	0	1	1	1	1	0
442	Bird	1	0	1	0	1	1	1	1	0
443	Bird	1	0	1	0	1	1	1	1	0
444	Bird	1	0	0	1	1	1	1	1	0
445	Bird	1	0	0	1	1	1	1	1	0
446	Bird	1	0	0	1	1	1	1	1	0
447	Bird	1	0	1	0	1	1	1	1	0
448	Bird	1	0	1	0	1	1	1	1	0
449	Bird	1	0	1	0	1	1	1	1	0
450	Bird	1	0	0	1	1	1	1	1	0
451	Bird	1	0	0	1	1	1	1	1	0
452	Bird	1	0	0	1	1	1	1	1	0
453	Bird	1	0	1	0	1	1	1	1	0
454	Bird	1	0	1	0	1	1	1	1	0
455	Bird	1	0	1	0	1	1	1	1	0
456	Bird	1	0	0	1	1	1	1	1	0
457	Bird	1	0	0	1	1	1	1	1	0
458	Bird	1	0	0	1	1	1	1	1	0
459	Bird	1	0	1	0	1	1	1	1	0
460	Bird	1	0	1	0	1	1	1	1	0
461	Bird	1	0	1	0	1	1	1	1	0
462	Bird	1	0	0	1	1	1	1	1	0
463	Bird	1	0	0	1	1	1	1	1	0
464	Bird	1	0	0	1	1	1	1	1	0
465	Bird	1	0	1	0	1	1	1	1	0
466	Bird	1	0	1	0	1	1	1	1	0

Appendix 2

Idealized Trait Combinations		Odor Strength		Scent Type					
Number	Pollination Syndrome	Strong	None	Sweet	Fruity	Fresh	Musky	Sour	Decaying
428	Bird	0	1	0	0	0	0	0	0
429	Bird	0	1	0	0	0	0	0	0
430	Bird	0	1	0	0	0	0	0	0
431	Bird	0	1	0	0	0	0	0	0
432	Bird	0	1	0	0	0	0	0	0
433	Bird	0	1	0	0	0	0	0	0
434	Bird	0	1	0	0	0	0	0	0
435	Bird	0	1	0	0	0	0	0	0
436	Bird	0	1	0	0	0	0	0	0
437	Bird	0	1	0	0	0	0	0	0
438	Bird	0	1	0	0	0	0	0	0
439	Bird	0	1	0	0	0	0	0	0
440	Bird	0	1	0	0	0	0	0	0
441	Bird	0	1	0	0	0	0	0	0
442	Bird	0	1	0	0	0	0	0	0
443	Bird	0	1	0	0	0	0	0	0
444	Bird	0	1	0	0	0	0	0	0
445	Bird	0	1	0	0	0	0	0	0
446	Bird	0	1	0	0	0	0	0	0
447	Bird	0	1	0	0	0	0	0	0
448	Bird	0	1	0	0	0	0	0	0
449	Bird	0	1	0	0	0	0	0	0
450	Bird	0	1	0	0	0	0	0	0
451	Bird	0	1	0	0	0	0	0	0
452	Bird	0	1	0	0	0	0	0	0
453	Bird	0	1	0	0	0	0	0	0
454	Bird	0	1	0	0	0	0	0	0
455	Bird	0	1	0	0	0	0	0	0
456	Bird	0	1	0	0	0	0	0	0
457	Bird	0	1	0	0	0	0	0	0
458	Bird	0	1	0	0	0	0	0	0
459	Bird	0	1	0	0	0	0	0	0
460	Bird	0	1	0	0	0	0	0	0
461	Bird	0	1	0	0	0	0	0	0
462	Bird	0	1	0	0	0	0	0	0
463	Bird	0	1	0	0	0	0	0	0
464	Bird	0	1	0	0	0	0	0	0
465	Bird	0	1	0	0	0	0	0	0
466	Bird	0	1	0	0	0	0	0	0

Appendix 2

Idealized Trait Combinations		Color Brightness	Color						
Number	Pollination Syndrome	Vivid	Brown	White	Red	Green	Yellow	Blue	Purple
428	Bird	1	0	0	0	0	0	1	0
429	Bird	1	0	0	1	0	0	0	0
430	Bird	1	0	0	0	1	0	0	0
431	Bird	1	0	0	0	0	0	1	0
432	Bird	1	0	0	1	0	0	0	0
433	Bird	1	0	0	0	1	0	0	0
434	Bird	1	0	0	0	0	0	1	0
435	Bird	1	0	0	1	0	0	0	0
436	Bird	1	0	0	0	1	0	0	0
437	Bird	1	0	0	0	0	0	1	0
438	Bird	1	0	0	1	0	0	0	0
439	Bird	1	0	0	0	1	0	0	0
440	Bird	1	0	0	0	0	0	1	0
441	Bird	1	0	0	1	0	0	0	0
442	Bird	1	0	0	0	1	0	0	0
443	Bird	1	0	0	0	0	0	1	0
444	Bird	1	0	0	1	0	0	0	0
445	Bird	1	0	0	0	1	0	0	0
446	Bird	1	0	0	0	0	0	1	0
447	Bird	1	0	0	1	0	0	0	0
448	Bird	1	0	0	0	1	0	0	0
449	Bird	1	0	0	0	0	0	1	0
450	Bird	1	0	0	1	0	0	0	0
451	Bird	1	0	0	0	1	0	0	0
452	Bird	1	0	0	0	0	0	1	0
453	Bird	1	0	0	1	0	0	0	0
454	Bird	1	0	0	0	1	0	0	0
455	Bird	1	0	0	0	0	0	1	0
456	Bird	1	0	0	1	0	0	0	0
457	Bird	1	0	0	0	1	0	0	0
458	Bird	1	0	0	0	0	0	1	0
459	Bird	1	0	0	1	0	0	0	0
460	Bird	1	0	0	0	1	0	0	0
461	Bird	1	0	0	0	0	0	1	0
462	Bird	1	0	0	1	0	0	0	0
463	Bird	1	0	0	0	1	0	0	0
464	Bird	1	0	0	0	0	0	1	0
465	Bird	1	0	0	1	0	0	0	0
466	Bird	1	0	0	0	1	0	0	0

Appendix 2

Idealized Trait Combinations		Flower Shape							Size	
Number	Pollination Syndrome	Trap	Open	Bell	Brush	Gullet	Flag	Tube	Medium/ Small	Mechanically Strong
467	Bird	0	0	0	0	0	1	0	1	1
468	Bird	0	0	0	0	0	1	0	1	1
469	Bird	0	0	0	0	0	1	0	1	1
470	Bird	0	0	0	0	0	1	0	1	1
471	Bird	0	0	0	0	0	1	0	1	1
472	Bird	0	0	0	0	0	1	0	1	1
473	Bird	0	0	0	0	0	1	0	1	1
474	Bird	0	0	0	0	0	1	0	1	1
475	Bird	0	0	0	0	0	1	0	1	1
476	Bird	0	0	0	0	0	1	0	1	1
477	Bird	0	0	0	0	0	1	0	1	1
478	Bird	0	0	0	0	0	1	0	1	1
479	Bird	0	0	0	0	0	1	0	1	1
480	Bird	0	0	0	0	0	1	0	1	1
481	Bird	0	0	0	0	0	1	0	1	1
482	Bird	0	0	0	0	0	1	0	1	1
483	Bird	0	0	0	0	0	0	1	0	1
484	Bird	0	0	0	0	0	0	1	0	1
485	Bird	0	0	0	0	0	0	1	0	1
486	Bird	0	0	0	0	0	0	1	0	1
487	Bird	0	0	0	0	0	0	1	0	1
488	Bird	0	0	0	0	0	0	1	0	1
489	Bird	0	0	0	0	0	0	1	0	1
490	Bird	0	0	0	0	0	0	1	0	1
491	Bird	0	0	0	0	0	0	1	0	1
492	Bird	0	0	0	0	0	0	1	0	1
493	Bird	0	0	0	0	0	0	1	0	1
494	Bird	0	0	0	0	0	0	1	0	1
495	Bird	0	0	0	0	0	0	1	0	1
496	Bird	0	0	0	0	0	0	1	0	1
497	Bird	0	0	0	0	0	0	1	1	1
498	Bird	0	0	0	0	0	0	1	1	1
499	Bird	0	0	0	0	0	0	1	1	1
500	Bird	0	0	0	0	0	0	1	1	1
501	Bird	0	0	0	0	0	0	1	1	1
502	Bird	0	0	0	0	0	0	1	1	1
503	Bird	0	0	0	0	0	0	1	1	1
504	Bird	0	0	0	0	0	0	1	1	1
505	Bird	0	0	0	0	0	0	1	1	1

Appendix 2

Idealized Trait Combinations		Symmetry	Anthers		Flower Orientation		
Number	Pollination Syndrome	Zygomorphic	Stiff	Exposed	Pendant	Upright	Horizontal
467	Bird	0	1	1	1	0	0
468	Bird	0	1	1	1	0	0
469	Bird	0	1	1	1	0	0
470	Bird	0	1	1	1	0	0
471	Bird	0	1	1	0	1	0
472	Bird	0	1	1	0	1	0
473	Bird	0	1	1	0	1	0
474	Bird	0	1	1	0	1	0
475	Bird	0	1	1	0	1	0
476	Bird	0	1	1	0	1	0
477	Bird	0	1	1	0	0	1
478	Bird	0	1	1	0	0	1
479	Bird	0	1	1	0	0	1
480	Bird	0	1	1	0	0	1
481	Bird	0	1	1	0	0	1
482	Bird	0	1	1	0	0	1
483	Bird	0	1	1	1	0	0
484	Bird	0	1	1	1	0	0
485	Bird	0	1	1	1	0	0
486	Bird	0	1	1	1	0	0
487	Bird	0	1	1	1	0	0
488	Bird	0	1	1	1	0	0
489	Bird	0	1	1	0	1	0
490	Bird	0	1	1	0	1	0
491	Bird	0	1	1	0	1	0
492	Bird	0	1	1	0	1	0
493	Bird	0	1	1	0	1	0
494	Bird	0	1	1	0	1	0
495	Bird	0	1	1	0	0	1
496	Bird	0	1	1	0	0	1
497	Bird	0	1	1	1	0	0
498	Bird	0	1	1	1	0	0
499	Bird	0	1	1	1	0	0
500	Bird	0	1	1	1	0	0
501	Bird	0	1	1	0	1	0
502	Bird	0	1	1	0	1	0
503	Bird	0	1	1	0	1	0
504	Bird	0	1	1	0	1	0
505	Bird	0	1	1	0	1	0

Appendix 2

Idealized Trait Combinations		Tube Morphology				Time of Opening	Nectar		Nectar Volume	
Number	Pollination Syndrome	Narrow	Wide	Short	Long	Day	Guides	Present	Abundant	Moderate
467	Bird	1	0	1	0	1	1	1	1	0
468	Bird	1	0	0	1	1	1	1	1	0
469	Bird	1	0	0	1	1	1	1	1	0
470	Bird	1	0	0	1	1	1	1	1	0
471	Bird	1	0	1	0	1	1	1	1	0
472	Bird	1	0	1	0	1	1	1	1	0
473	Bird	1	0	1	0	1	1	1	1	0
474	Bird	1	0	0	1	1	1	1	1	0
475	Bird	1	0	0	1	1	1	1	1	0
476	Bird	1	0	0	1	1	1	1	1	0
477	Bird	1	0	1	0	1	1	1	1	0
478	Bird	1	0	1	0	1	1	1	1	0
479	Bird	1	0	1	0	1	1	1	1	0
480	Bird	1	0	0	1	1	1	1	1	0
481	Bird	1	0	0	1	1	1	1	1	0
482	Bird	1	0	0	1	1	1	1	1	0
483	Bird	1	0	1	0	1	1	1	1	0
484	Bird	1	0	1	0	1	1	1	1	0
485	Bird	1	0	1	0	1	1	1	1	0
486	Bird	1	0	0	1	1	1	1	1	0
487	Bird	1	0	0	1	1	1	1	1	0
488	Bird	1	0	0	1	1	1	1	1	0
489	Bird	1	0	1	0	1	1	1	1	0
490	Bird	1	0	1	0	1	1	1	1	0
491	Bird	1	0	1	0	1	1	1	1	0
492	Bird	1	0	0	1	1	1	1	1	0
493	Bird	1	0	0	1	1	1	1	1	0
494	Bird	1	0	0	1	1	1	1	1	0
495	Bird	1	0	1	0	1	1	1	1	0
496	Bird	1	0	0	1	1	1	1	1	0
497	Bird	1	0	1	0	1	1	1	1	0
498	Bird	1	0	0	1	1	1	1	1	0
499	Bird	1	0	0	1	1	1	1	1	0
500	Bird	1	0	0	1	1	1	1	1	0
501	Bird	1	0	1	0	1	1	1	1	0
502	Bird	1	0	1	0	1	1	1	1	0
503	Bird	1	0	1	0	1	1	1	1	0
504	Bird	1	0	0	1	1	1	1	1	0
505	Bird	1	0	0	1	1	1	1	1	0

Appendix 2

Idealized Trait Combinations		Odor Strength		Scent Type					
Number	Pollination Syndrome	Strong	None	Sweet	Fruity	Fresh	Musky	Sour	Decaying
467	Bird	0	1	0	0	0	0	0	0
468	Bird	0	1	0	0	0	0	0	0
469	Bird	0	1	0	0	0	0	0	0
470	Bird	0	1	0	0	0	0	0	0
471	Bird	0	1	0	0	0	0	0	0
472	Bird	0	1	0	0	0	0	0	0
473	Bird	0	1	0	0	0	0	0	0
474	Bird	0	1	0	0	0	0	0	0
475	Bird	0	1	0	0	0	0	0	0
476	Bird	0	1	0	0	0	0	0	0
477	Bird	0	1	0	0	0	0	0	0
478	Bird	0	1	0	0	0	0	0	0
479	Bird	0	1	0	0	0	0	0	0
480	Bird	0	1	0	0	0	0	0	0
481	Bird	0	1	0	0	0	0	0	0
482	Bird	0	1	0	0	0	0	0	0
483	Bird	0	1	0	0	0	0	0	0
484	Bird	0	1	0	0	0	0	0	0
485	Bird	0	1	0	0	0	0	0	0
486	Bird	0	1	0	0	0	0	0	0
487	Bird	0	1	0	0	0	0	0	0
488	Bird	0	1	0	0	0	0	0	0
489	Bird	0	1	0	0	0	0	0	0
490	Bird	0	1	0	0	0	0	0	0
491	Bird	0	1	0	0	0	0	0	0
492	Bird	0	1	0	0	0	0	0	0
493	Bird	0	1	0	0	0	0	0	0
494	Bird	0	1	0	0	0	0	0	0
495	Bird	0	1	0	0	0	0	0	0
496	Bird	0	1	0	0	0	0	0	0
497	Bird	0	1	0	0	0	0	0	0
498	Bird	0	1	0	0	0	0	0	0
499	Bird	0	1	0	0	0	0	0	0
500	Bird	0	1	0	0	0	0	0	0
501	Bird	0	1	0	0	0	0	0	0
502	Bird	0	1	0	0	0	0	0	0
503	Bird	0	1	0	0	0	0	0	0
504	Bird	0	1	0	0	0	0	0	0
505	Bird	0	1	0	0	0	0	0	0

Appendix 2

Idealized Trait Combinations		Color Brightness	Color						
Number	Pollination Syndrome	Vivid	Brown	White	Red	Green	Yellow	Blue	Purple
467	Bird	1	0	0	0	0	0	1	0
468	Bird	1	0	0	1	0	0	0	0
469	Bird	1	0	0	0	1	0	0	0
470	Bird	1	0	0	0	0	0	1	0
471	Bird	1	0	0	1	0	0	0	0
472	Bird	1	0	0	0	1	0	0	0
473	Bird	1	0	0	0	0	0	1	0
474	Bird	1	0	0	1	0	0	0	0
475	Bird	1	0	0	0	1	0	0	0
476	Bird	1	0	0	0	0	0	1	0
477	Bird	1	0	0	1	0	0	0	0
478	Bird	1	0	0	0	1	0	0	0
479	Bird	1	0	0	0	0	0	1	0
480	Bird	1	0	0	1	0	0	0	0
481	Bird	1	0	0	0	1	0	0	0
482	Bird	1	0	0	0	0	0	1	0
483	Bird	1	0	0	1	0	0	0	0
484	Bird	1	0	0	0	1	0	0	0
485	Bird	1	0	0	0	0	0	1	0
486	Bird	1	0	0	1	0	0	0	0
487	Bird	1	0	0	0	1	0	0	0
488	Bird	1	0	0	0	0	0	1	0
489	Bird	1	0	0	1	0	0	0	0
490	Bird	1	0	0	0	1	0	0	0
491	Bird	1	0	0	0	0	0	1	0
492	Bird	1	0	0	1	0	0	0	0
493	Bird	1	0	0	0	1	0	0	0
494	Bird	1	0	0	0	0	0	1	0
495	Bird	1	0	0	1	0	0	0	0
496	Bird	1	0	0	0	1	0	0	0
497	Bird	1	0	0	0	0	0	1	0
498	Bird	1	0	0	1	0	0	0	0
499	Bird	1	0	0	0	1	0	0	0
500	Bird	1	0	0	0	0	0	1	0
501	Bird	1	0	0	1	0	0	0	0
502	Bird	1	0	0	0	1	0	0	0
503	Bird	1	0	0	0	0	0	1	0
504	Bird	1	0	0	1	0	0	0	0
505	Bird	1	0	0	0	1	0	0	0

Appendix 2

Idealized Trait Combinations		Flower Shape							Size	
Number	Pollination Syndrome	Trap	Open	Bell	Brush	Gullet	Flag	Tube	Medium/ Small	Mechanically Strong
506	Bird	0	0	0	0	0	0	1	1	1
507	Bird	0	0	0	0	0	0	1	1	1
508	Bird	0	0	0	0	0	0	1	1	1
509	Bird	0	0	0	0	0	0	1	1	1
510	Bird	0	0	0	0	0	0	1	1	1
511	Bird	0	0	0	0	0	0	1	1	1
512	Bird	0	0	0	0	0	0	1	1	1
513	Fly	1	0	0	0	0	0	0	1	0
514	Fly	1	0	0	0	0	0	0	1	0
515	Fly	1	0	0	0	0	0	0	1	0
516	Fly	0	1	0	0	0	0	0	1	0
517	Fly	0	1	0	0	0	0	0	1	0
518	Fly	0	1	0	0	0	0	0	1	0
519	Fly	0	0	1	0	0	0	0	1	0
520	Fly	0	0	1	0	0	0	0	1	0
521	Fly	0	0	1	0	0	0	0	1	0
522	Fly	1	0	0	0	0	0	0	1	0
523	Fly	1	0	0	0	0	0	0	1	0
524	Fly	1	0	0	0	0	0	0	1	0
525	Fly	0	1	0	0	0	0	0	1	0
526	Fly	0	1	0	0	0	0	0	1	0
527	Fly	0	1	0	0	0	0	0	1	0
528	Fly	0	0	1	0	0	0	0	1	0
529	Fly	0	0	1	0	0	0	0	1	0
530	Fly	0	0	1	0	0	0	0	1	0
531	Fly	1	0	0	0	0	0	0	1	0
532	Fly	1	0	0	0	0	0	0	1	0
533	Fly	1	0	0	0	0	0	0	1	0
534	Fly	0	1	0	0	0	0	0	1	0
535	Fly	0	1	0	0	0	0	0	1	0
536	Fly	0	1	0	0	0	0	0	1	0
537	Fly	0	0	1	0	0	0	0	1	0
538	Fly	0	0	1	0	0	0	0	1	0
539	Fly	0	0	1	0	0	0	0	1	0
540	Fly	1	0	0	0	0	0	0	1	0
541	Fly	1	0	0	0	0	0	0	1	0
542	Fly	1	0	0	0	0	0	0	1	0
543	Fly	0	1	0	0	0	0	0	1	0
544	Fly	0	1	0	0	0	0	0	1	0

Appendix 2

Idealized Trait Combinations		Symmetry	Anthers		Flower Orientation		
Number	Pollination Syndrome	Zygomorphic	Stiff	Exposed	Pendant	Upright	Horizontal
506	Bird	0	1	1	0	1	0
507	Bird	0	1	1	0	0	1
508	Bird	0	1	1	0	0	1
509	Bird	0	1	1	0	0	1
510	Bird	0	1	1	0	0	1
511	Bird	0	1	1	0	0	1
512	Bird	0	1	1	0	0	1
513	Fly	0	0	1	1	0	0
514	Fly	0	0	1	0	1	0
515	Fly	0	0	1	0	0	1
516	Fly	0	0	1	1	0	0
517	Fly	0	0	1	0	1	0
518	Fly	0	0	1	0	0	1
519	Fly	0	0	1	1	0	0
520	Fly	0	0	1	0	1	0
521	Fly	0	0	1	0	0	1
522	Fly	0	0	1	1	0	0
523	Fly	0	0	1	0	1	0
524	Fly	0	0	1	0	0	1
525	Fly	0	0	1	1	0	0
526	Fly	0	0	1	0	1	0
527	Fly	0	0	1	0	0	1
528	Fly	0	0	1	1	0	0
529	Fly	0	0	1	0	1	0
530	Fly	0	0	1	0	0	1
531	Fly	0	0	1	1	0	0
532	Fly	0	0	1	0	1	0
533	Fly	0	0	1	0	0	1
534	Fly	0	0	1	1	0	0
535	Fly	0	0	1	0	1	0
536	Fly	0	0	1	0	0	1
537	Fly	0	0	1	1	0	0
538	Fly	0	0	1	0	1	0
539	Fly	0	0	1	0	0	1
540	Fly	0	0	1	1	0	0
541	Fly	0	0	1	0	1	0
542	Fly	0	0	1	0	0	1
543	Fly	0	0	1	1	0	0
544	Fly	0	0	1	0	1	0

Appendix 2

Idealized Trait Combinations		Tube Morphology				Time of Opening	Nectar		Nectar Volume	
Number	Pollination Syndrome	Narrow	Wide	Short	Long	Day	Guides	Present	Abundant	Moderate
506	Bird	1	0	0	1	1	1	1	1	0
507	Bird	1	0	1	0	1	1	1	1	0
508	Bird	1	0	1	0	1	1	1	1	0
509	Bird	1	0	1	0	1	1	1	1	0
510	Bird	1	0	0	1	1	1	1	1	0
511	Bird	1	0	0	1	1	1	1	1	0
512	Bird	1	0	0	1	1	1	1	1	0
513	Fly	0	0	0	0	1	1	1	0	0
514	Fly	0	0	0	0	1	1	1	0	0
515	Fly	0	0	0	0	1	1	1	0	0
516	Fly	0	0	0	0	1	1	1	0	0
517	Fly	0	0	0	0	1	1	1	0	0
518	Fly	0	0	0	0	1	1	1	0	0
519	Fly	0	0	0	0	1	1	1	0	0
520	Fly	0	0	0	0	1	1	1	0	0
521	Fly	0	0	0	0	1	1	1	0	0
522	Fly	0	0	0	0	1	1	1	0	0
523	Fly	0	0	0	0	1	1	1	0	0
524	Fly	0	0	0	0	1	1	1	0	0
525	Fly	0	0	0	0	1	1	1	0	0
526	Fly	0	0	0	0	1	1	1	0	0
527	Fly	0	0	0	0	1	1	1	0	0
528	Fly	0	0	0	0	1	1	1	0	0
529	Fly	0	0	0	0	1	1	1	0	0
530	Fly	0	0	0	0	1	1	1	0	0
531	Fly	0	0	0	0	1	1	1	0	0
532	Fly	0	0	0	0	1	1	1	0	0
533	Fly	0	0	0	0	1	1	1	0	0
534	Fly	0	0	0	0	1	1	1	0	0
535	Fly	0	0	0	0	1	1	1	0	0
536	Fly	0	0	0	0	1	1	1	0	0
537	Fly	0	0	0	0	1	1	1	0	0
538	Fly	0	0	0	0	1	1	1	0	0
539	Fly	0	0	0	0	1	1	1	0	0
540	Fly	0	0	0	0	1	1	1	0	0
541	Fly	0	0	0	0	1	1	1	0	0
542	Fly	0	0	0	0	1	1	1	0	0
543	Fly	0	0	0	0	1	1	1	0	0
544	Fly	0	0	0	0	1	1	1	0	0

Appendix 2

Idealized Trait Combinations		Odor Strength		Scent Type					
Number	Pollination Syndrome	Strong	None	Sweet	Fruity	Fresh	Musky	Sour	Decaying
506	Bird	0	1	0	0	0	0	0	0
507	Bird	0	1	0	0	0	0	0	0
508	Bird	0	1	0	0	0	0	0	0
509	Bird	0	1	0	0	0	0	0	0
510	Bird	0	1	0	0	0	0	0	0
511	Bird	0	1	0	0	0	0	0	0
512	Bird	0	1	0	0	0	0	0	0
513	Fly	1	0	0	1	0	0	0	0
514	Fly	1	0	0	1	0	0	0	0
515	Fly	1	0	0	1	0	0	0	0
516	Fly	1	0	0	1	0	0	0	0
517	Fly	1	0	0	1	0	0	0	0
518	Fly	1	0	0	1	0	0	0	0
519	Fly	1	0	0	1	0	0	0	0
520	Fly	1	0	0	1	0	0	0	0
521	Fly	1	0	0	1	0	0	0	0
522	Fly	1	0	0	0	0	0	1	0
523	Fly	1	0	0	0	0	0	1	0
524	Fly	1	0	0	0	0	0	1	0
525	Fly	1	0	0	0	0	0	1	0
526	Fly	1	0	0	0	0	0	1	0
527	Fly	1	0	0	0	0	0	1	0
528	Fly	1	0	0	0	0	0	1	0
529	Fly	1	0	0	0	0	0	1	0
530	Fly	1	0	0	0	0	0	1	0
531	Fly	1	0	0	0	0	0	0	1
532	Fly	1	0	0	0	0	0	0	1
533	Fly	1	0	0	0	0	0	0	1
534	Fly	1	0	0	0	0	0	0	1
535	Fly	1	0	0	0	0	0	0	1
536	Fly	1	0	0	0	0	0	0	1
537	Fly	1	0	0	0	0	0	0	1
538	Fly	1	0	0	0	0	0	0	1
539	Fly	1	0	0	0	0	0	0	1
540	Fly	1	0	0	1	0	0	0	0
541	Fly	1	0	0	1	0	0	0	0
542	Fly	1	0	0	1	0	0	0	0
543	Fly	1	0	0	1	0	0	0	0
544	Fly	1	0	0	1	0	0	0	0

Appendix 2

Idealized Trait Combinations		Color Brightness	Color						
Number	Pollination Syndrome	Vivid	Brown	White	Red	Green	Yellow	Blue	Purple
506	Bird	1	0	0	0	0	0	1	0
507	Bird	1	0	0	1	0	0	0	0
508	Bird	1	0	0	0	1	0	0	0
509	Bird	1	0	0	0	0	0	1	0
510	Bird	1	0	0	1	0	0	0	0
511	Bird	1	0	0	0	1	0	0	0
512	Bird	1	0	0	0	0	0	1	0
513	Fly	0	1	0	0	0	0	0	0
514	Fly	0	1	0	0	0	0	0	0
515	Fly	0	1	0	0	0	0	0	0
516	Fly	0	1	0	0	0	0	0	0
517	Fly	0	1	0	0	0	0	0	0
518	Fly	0	1	0	0	0	0	0	0
519	Fly	0	1	0	0	0	0	0	0
520	Fly	0	1	0	0	0	0	0	0
521	Fly	0	1	0	0	0	0	0	0
522	Fly	0	1	0	0	0	0	0	0
523	Fly	0	1	0	0	0	0	0	0
524	Fly	0	1	0	0	0	0	0	0
525	Fly	0	1	0	0	0	0	0	0
526	Fly	0	1	0	0	0	0	0	0
527	Fly	0	1	0	0	0	0	0	0
528	Fly	0	1	0	0	0	0	0	0
529	Fly	0	1	0	0	0	0	0	0
530	Fly	0	1	0	0	0	0	0	0
531	Fly	0	1	0	0	0	0	0	0
532	Fly	0	1	0	0	0	0	0	0
533	Fly	0	1	0	0	0	0	0	0
534	Fly	0	1	0	0	0	0	0	0
535	Fly	0	1	0	0	0	0	0	0
536	Fly	0	1	0	0	0	0	0	0
537	Fly	0	1	0	0	0	0	0	0
538	Fly	0	1	0	0	0	0	0	0
539	Fly	0	1	0	0	0	0	0	0
540	Fly	0	0	1	0	0	0	0	0
541	Fly	0	0	1	0	0	0	0	0
542	Fly	0	0	1	0	0	0	0	0
543	Fly	0	0	1	0	0	0	0	0
544	Fly	0	0	1	0	0	0	0	0

Appendix 2

Idealized Trait Combinations		Flower Shape							Size	
Number	Pollination Syndrome	Trap	Open	Bell	Brush	Gullet	Flag	Tube	Medium/ Small	Mechanically Strong
545	Fly	0	1	0	0	0	0	0	1	0
546	Fly	0	0	1	0	0	0	0	1	0
547	Fly	0	0	1	0	0	0	0	1	0
548	Fly	0	0	1	0	0	0	0	1	0
549	Fly	1	0	0	0	0	0	0	1	0
550	Fly	1	0	0	0	0	0	0	1	0
551	Fly	1	0	0	0	0	0	0	1	0
552	Fly	0	1	0	0	0	0	0	1	0
553	Fly	0	1	0	0	0	0	0	1	0
554	Fly	0	1	0	0	0	0	0	1	0
555	Fly	0	0	1	0	0	0	0	1	0
556	Fly	0	0	1	0	0	0	0	1	0
557	Fly	0	0	1	0	0	0	0	1	0
558	Fly	1	0	0	0	0	0	0	1	0
559	Fly	1	0	0	0	0	0	0	1	0
560	Fly	1	0	0	0	0	0	0	1	0
561	Fly	0	1	0	0	0	0	0	1	0
562	Fly	0	1	0	0	0	0	0	1	0
563	Fly	0	1	0	0	0	0	0	1	0
564	Fly	0	0	1	0	0	0	0	1	0
565	Fly	0	0	1	0	0	0	0	1	0
566	Fly	0	0	1	0	0	0	0	1	0
567	Fly	1	0	0	0	0	0	0	1	0
568	Fly	1	0	0	0	0	0	0	1	0
569	Fly	1	0	0	0	0	0	0	1	0
570	Fly	0	1	0	0	0	0	0	1	0
571	Fly	0	1	0	0	0	0	0	1	0
572	Fly	0	1	0	0	0	0	0	1	0
573	Fly	0	0	1	0	0	0	0	1	0
574	Fly	0	0	1	0	0	0	0	1	0
575	Fly	0	0	1	0	0	0	0	1	0
576	Fly	1	0	0	0	0	0	0	1	0
577	Fly	1	0	0	0	0	0	0	1	0
578	Fly	1	0	0	0	0	0	0	1	0
579	Fly	0	1	0	0	0	0	0	1	0
580	Fly	0	1	0	0	0	0	0	1	0
581	Fly	0	1	0	0	0	0	0	1	0
582	Fly	0	0	1	0	0	0	0	1	0
583	Fly	0	0	1	0	0	0	0	1	0

Appendix 2

Idealized Trait Combinations		Symmetry	Anthers		Flower Orientation		
Number	Pollination Syndrome	Zygomorphic	Stiff	Exposed	Pendant	Upright	Horizontal
545	Fly	0	0	1	0	0	1
546	Fly	0	0	1	1	0	0
547	Fly	0	0	1	0	1	0
548	Fly	0	0	1	0	0	1
549	Fly	0	0	1	1	0	0
550	Fly	0	0	1	0	1	0
551	Fly	0	0	1	0	0	1
552	Fly	0	0	1	1	0	0
553	Fly	0	0	1	0	1	0
554	Fly	0	0	1	0	0	1
555	Fly	0	0	1	1	0	0
556	Fly	0	0	1	0	1	0
557	Fly	0	0	1	0	0	1
558	Fly	0	0	1	1	0	0
559	Fly	0	0	1	0	1	0
560	Fly	0	0	1	0	0	1
561	Fly	0	0	1	1	0	0
562	Fly	0	0	1	0	1	0
563	Fly	0	0	1	0	0	1
564	Fly	0	0	1	1	0	0
565	Fly	0	0	1	0	1	0
566	Fly	0	0	1	0	0	1
567	Fly	0	0	1	1	0	0
568	Fly	0	0	1	0	1	0
569	Fly	0	0	1	0	0	1
570	Fly	0	0	1	1	0	0
571	Fly	0	0	1	0	1	0
572	Fly	0	0	1	0	0	1
573	Fly	0	0	1	1	0	0
574	Fly	0	0	1	0	1	0
575	Fly	0	0	1	0	0	1
576	Fly	0	0	1	1	0	0
577	Fly	0	0	1	0	1	0
578	Fly	0	0	1	0	0	1
579	Fly	0	0	1	1	0	0
580	Fly	0	0	1	0	1	0
581	Fly	0	0	1	0	0	1
582	Fly	0	0	1	1	0	0
583	Fly	0	0	1	0	1	0

Appendix 2

Idealized Trait Combinations		Tube Morphology				Time of Opening	Nectar		Nectar Volume	
Number	Pollination Syndrome	Narrow	Wide	Short	Long	Day	Guides	Present	Abundant	Moderate
545	Fly	0	0	0	0	1	1	1	0	0
546	Fly	0	0	0	0	1	1	1	0	0
547	Fly	0	0	0	0	1	1	1	0	0
548	Fly	0	0	0	0	1	1	1	0	0
549	Fly	0	0	0	0	1	1	1	0	0
550	Fly	0	0	0	0	1	1	1	0	0
551	Fly	0	0	0	0	1	1	1	0	0
552	Fly	0	0	0	0	1	1	1	0	0
553	Fly	0	0	0	0	1	1	1	0	0
554	Fly	0	0	0	0	1	1	1	0	0
555	Fly	0	0	0	0	1	1	1	0	0
556	Fly	0	0	0	0	1	1	1	0	0
557	Fly	0	0	0	0	1	1	1	0	0
558	Fly	0	0	0	0	1	1	1	0	0
559	Fly	0	0	0	0	1	1	1	0	0
560	Fly	0	0	0	0	1	1	1	0	0
561	Fly	0	0	0	0	1	1	1	0	0
562	Fly	0	0	0	0	1	1	1	0	0
563	Fly	0	0	0	0	1	1	1	0	0
564	Fly	0	0	0	0	1	1	1	0	0
565	Fly	0	0	0	0	1	1	1	0	0
566	Fly	0	0	0	0	1	1	1	0	0
567	Fly	0	0	0	0	1	1	1	0	0
568	Fly	0	0	0	0	1	1	1	0	0
569	Fly	0	0	0	0	1	1	1	0	0
570	Fly	0	0	0	0	1	1	1	0	0
571	Fly	0	0	0	0	1	1	1	0	0
572	Fly	0	0	0	0	1	1	1	0	0
573	Fly	0	0	0	0	1	1	1	0	0
574	Fly	0	0	0	0	1	1	1	0	0
575	Fly	0	0	0	0	1	1	1	0	0
576	Fly	0	0	0	0	1	1	1	0	0
577	Fly	0	0	0	0	1	1	1	0	0
578	Fly	0	0	0	0	1	1	1	0	0
579	Fly	0	0	0	0	1	1	1	0	0
580	Fly	0	0	0	0	1	1	1	0	0
581	Fly	0	0	0	0	1	1	1	0	0
582	Fly	0	0	0	0	1	1	1	0	0
583	Fly	0	0	0	0	1	1	1	0	0

Appendix 2

Idealized Trait Combinations		Odor Strength		Scent Type					
Number	Pollination Syndrome	Strong	None	Sweet	Fruity	Fresh	Musky	Sour	Decaying
545	Fly	1	0	0	1	0	0	0	0
546	Fly	1	0	0	1	0	0	0	0
547	Fly	1	0	0	1	0	0	0	0
548	Fly	1	0	0	1	0	0	0	0
549	Fly	1	0	0	0	0	0	1	0
550	Fly	1	0	0	0	0	0	1	0
551	Fly	1	0	0	0	0	0	1	0
552	Fly	1	0	0	0	0	0	1	0
553	Fly	1	0	0	0	0	0	1	0
554	Fly	1	0	0	0	0	0	1	0
555	Fly	1	0	0	0	0	0	1	0
556	Fly	1	0	0	0	0	0	1	0
557	Fly	1	0	0	0	0	0	1	0
558	Fly	1	0	0	0	0	0	0	1
559	Fly	1	0	0	0	0	0	0	1
560	Fly	1	0	0	0	0	0	0	1
561	Fly	1	0	0	0	0	0	0	1
562	Fly	1	0	0	0	0	0	0	1
563	Fly	1	0	0	0	0	0	0	1
564	Fly	1	0	0	0	0	0	0	1
565	Fly	1	0	0	0	0	0	0	1
566	Fly	1	0	0	0	0	0	0	1
567	Fly	1	0	0	1	0	0	0	0
568	Fly	1	0	0	1	0	0	0	0
569	Fly	1	0	0	1	0	0	0	0
570	Fly	1	0	0	1	0	0	0	0
571	Fly	1	0	0	1	0	0	0	0
572	Fly	1	0	0	1	0	0	0	0
573	Fly	1	0	0	1	0	0	0	0
574	Fly	1	0	0	1	0	0	0	0
575	Fly	1	0	0	1	0	0	0	0
576	Fly	1	0	0	0	0	0	1	0
577	Fly	1	0	0	0	0	0	1	0
578	Fly	1	0	0	0	0	0	1	0
579	Fly	1	0	0	0	0	0	1	0
580	Fly	1	0	0	0	0	0	1	0
581	Fly	1	0	0	0	0	0	1	0
582	Fly	1	0	0	0	0	0	1	0
583	Fly	1	0	0	0	0	0	1	0

Appendix 2

Idealized Trait Combinations		Color Brightness	Color						
Number	Pollination Syndrome	Vivid	Brown	White	Red	Green	Yellow	Blue	Purple
545	Fly	0	0	1	0	0	0	0	0
546	Fly	0	0	1	0	0	0	0	0
547	Fly	0	0	1	0	0	0	0	0
548	Fly	0	0	1	0	0	0	0	0
549	Fly	0	0	1	0	0	0	0	0
550	Fly	0	0	1	0	0	0	0	0
551	Fly	0	0	1	0	0	0	0	0
552	Fly	0	0	1	0	0	0	0	0
553	Fly	0	0	1	0	0	0	0	0
554	Fly	0	0	1	0	0	0	0	0
555	Fly	0	0	1	0	0	0	0	0
556	Fly	0	0	1	0	0	0	0	0
557	Fly	0	0	1	0	0	0	0	0
558	Fly	0	0	1	0	0	0	0	0
559	Fly	0	0	1	0	0	0	0	0
560	Fly	0	0	1	0	0	0	0	0
561	Fly	0	0	1	0	0	0	0	0
562	Fly	0	0	1	0	0	0	0	0
563	Fly	0	0	1	0	0	0	0	0
564	Fly	0	0	1	0	0	0	0	0
565	Fly	0	0	1	0	0	0	0	0
566	Fly	0	0	1	0	0	0	0	0
567	Fly	0	0	0	0	0	1	0	0
568	Fly	0	0	0	0	0	1	0	0
569	Fly	0	0	0	0	0	1	0	0
570	Fly	0	0	0	0	0	1	0	0
571	Fly	0	0	0	0	0	1	0	0
572	Fly	0	0	0	0	0	1	0	0
573	Fly	0	0	0	0	0	1	0	0
574	Fly	0	0	0	0	0	1	0	0
575	Fly	0	0	0	0	0	1	0	0
576	Fly	0	0	0	0	0	1	0	0
577	Fly	0	0	0	0	0	1	0	0
578	Fly	0	0	0	0	0	1	0	0
579	Fly	0	0	0	0	0	1	0	0
580	Fly	0	0	0	0	0	1	0	0
581	Fly	0	0	0	0	0	1	0	0
582	Fly	0	0	0	0	0	1	0	0
583	Fly	0	0	0	0	0	1	0	0

Appendix 2

Idealized Trait Combinations		Flower Shape							Size	
Number	Pollination Syndrome	Trap	Open	Bell	Brush	Gullet	Flag	Tube	Medium/ Small	Mechanically Strong
584	Fly	0	0	1	0	0	0	0	1	0
585	Fly	1	0	0	0	0	0	0	1	0
586	Fly	1	0	0	0	0	0	0	1	0
587	Fly	1	0	0	0	0	0	0	1	0
588	Fly	0	1	0	0	0	0	0	1	0
589	Fly	0	1	0	0	0	0	0	1	0
590	Fly	0	1	0	0	0	0	0	1	0
591	Fly	0	0	1	0	0	0	0	1	0
592	Fly	0	0	1	0	0	0	0	1	0
593	Fly	0	0	1	0	0	0	0	1	0
594	Mammal	0	1	0	0	0	0	0	0	1
595	Mammal	0	0	1	0	0	0	0	0	1
596	Mammal	0	0	0	1	0	0	0	0	1
597	Mammal	0	1	0	0	0	0	0	0	1
598	Mammal	0	0	1	0	0	0	0	0	1
599	Mammal	0	0	0	1	0	0	0	0	1
600	Mammal	0	1	0	0	0	0	0	0	1
601	Mammal	0	0	1	0	0	0	0	0	1
602	Mammal	0	0	0	1	0	0	0	0	1
603	Mammal	0	1	0	0	0	0	0	0	1
604	Mammal	0	0	1	0	0	0	0	0	1
605	Mammal	0	0	0	1	0	0	0	0	1
606	Mammal	0	1	0	0	0	0	0	0	1
607	Mammal	0	0	1	0	0	0	0	0	1
608	Mammal	0	0	0	1	0	0	0	0	1
609	Mammal	0	1	0	0	0	0	0	0	1
610	Mammal	0	0	1	0	0	0	0	0	1
611	Mammal	0	0	0	1	0	0	0	0	1
612	Mammal	0	1	0	0	0	0	0	0	1
613	Mammal	0	0	1	0	0	0	0	0	1
614	Mammal	0	0	0	1	0	0	0	0	1
615	Mammal	0	1	0	0	0	0	0	0	1
616	Mammal	0	0	1	0	0	0	0	0	1
617	Mammal	0	0	0	1	0	0	0	0	1
618	Mammal	0	1	0	0	0	0	0	0	1
619	Mammal	0	0	1	0	0	0	0	0	1
620	Mammal	0	0	0	1	0	0	0	0	1
621	Mammal	0	1	0	0	0	0	0	0	1
622	Mammal	0	0	1	0	0	0	0	0	1

Appendix 2

Idealized Trait Combinations		Symmetry	Anthers		Flower Orientation		
Number	Pollination Syndrome	Zygomorphic	Stiff	Exposed	Pendant	Upright	Horizontal
584	Fly	0	0	1	0	0	1
585	Fly	0	0	1	1	0	0
586	Fly	0	0	1	0	1	0
587	Fly	0	0	1	0	0	1
588	Fly	0	0	1	1	0	0
589	Fly	0	0	1	0	1	0
590	Fly	0	0	1	0	0	1
591	Fly	0	0	1	1	0	0
592	Fly	0	0	1	0	1	0
593	Fly	0	0	1	0	0	1
594	Mammal	0	1	1	1	0	0
595	Mammal	0	1	1	1	0	0
596	Mammal	0	1	1	1	0	0
597	Mammal	0	1	1	0	1	0
598	Mammal	0	1	1	0	1	0
599	Mammal	0	1	1	0	1	0
600	Mammal	0	1	1	0	0	1
601	Mammal	0	1	1	0	0	1
602	Mammal	0	1	1	0	0	1
603	Mammal	0	1	1	1	0	0
604	Mammal	0	1	1	1	0	0
605	Mammal	0	1	1	1	0	0
606	Mammal	0	1	1	0	1	0
607	Mammal	0	1	1	0	1	0
608	Mammal	0	1	1	0	1	0
609	Mammal	0	1	1	0	0	1
610	Mammal	0	1	1	0	0	1
611	Mammal	0	1	1	0	0	1
612	Mammal	0	1	1	1	0	0
613	Mammal	0	1	1	1	0	0
614	Mammal	0	1	1	1	0	0
615	Mammal	0	1	1	0	1	0
616	Mammal	0	1	1	0	1	0
617	Mammal	0	1	1	0	1	0
618	Mammal	0	1	1	0	0	1
619	Mammal	0	1	1	0	0	1
620	Mammal	0	1	1	0	0	1
621	Mammal	0	1	1	1	0	0
622	Mammal	0	1	1	1	0	0

Appendix 2

Idealized Trait Combinations		Tube Morphology				Time of Opening	Nectar		Nectar Volume	
Number	Pollination Syndrome	Narrow	Wide	Short	Long	Day	Guides	Present	Abundant	Moderate
584	Fly	0	0	0	0	1	1	1	0	0
585	Fly	0	0	0	0	1	1	1	0	0
586	Fly	0	0	0	0	1	1	1	0	0
587	Fly	0	0	0	0	1	1	1	0	0
588	Fly	0	0	0	0	1	1	1	0	0
589	Fly	0	0	0	0	1	1	1	0	0
590	Fly	0	0	0	0	1	1	1	0	0
591	Fly	0	0	0	0	1	1	1	0	0
592	Fly	0	0	0	0	1	1	1	0	0
593	Fly	0	0	0	0	1	1	1	0	0
594	Mammal	0	0	0	0	0	0	1	1	0
595	Mammal	0	0	0	0	0	0	1	1	0
596	Mammal	0	0	0	0	0	0	1	1	0
597	Mammal	0	0	0	0	0	0	1	1	0
598	Mammal	0	0	0	0	0	0	1	1	0
599	Mammal	0	0	0	0	0	0	1	1	0
600	Mammal	0	0	0	0	0	0	1	1	0
601	Mammal	0	0	0	0	0	0	1	1	0
602	Mammal	0	0	0	0	0	0	1	1	0
603	Mammal	0	0	0	0	0	0	1	1	0
604	Mammal	0	0	0	0	0	0	1	1	0
605	Mammal	0	0	0	0	0	0	1	1	0
606	Mammal	0	0	0	0	0	0	1	1	0
607	Mammal	0	0	0	0	0	0	1	1	0
608	Mammal	0	0	0	0	0	0	1	1	0
609	Mammal	0	0	0	0	0	0	1	1	0
610	Mammal	0	0	0	0	0	0	1	1	0
611	Mammal	0	0	0	0	0	0	1	1	0
612	Mammal	0	0	0	0	0	0	1	1	0
613	Mammal	0	0	0	0	0	0	1	1	0
614	Mammal	0	0	0	0	0	0	1	1	0
615	Mammal	0	0	0	0	0	0	1	1	0
616	Mammal	0	0	0	0	0	0	1	1	0
617	Mammal	0	0	0	0	0	0	1	1	0
618	Mammal	0	0	0	0	0	0	1	1	0
619	Mammal	0	0	0	0	0	0	1	1	0
620	Mammal	0	0	0	0	0	0	1	1	0
621	Mammal	0	0	0	0	0	0	1	1	0
622	Mammal	0	0	0	0	0	0	1	1	0

Appendix 2

Idealized Trait Combinations		Odor Strength		Scent Type					
Number	Pollination Syndrome	Strong	None	Sweet	Fruity	Fresh	Musky	Sour	Decaying
584	Fly	1	0	0	0	0	0	1	0
585	Fly	1	0	0	0	0	0	0	1
586	Fly	1	0	0	0	0	0	0	1
587	Fly	1	0	0	0	0	0	0	1
588	Fly	1	0	0	0	0	0	0	1
589	Fly	1	0	0	0	0	0	0	1
590	Fly	1	0	0	0	0	0	0	1
591	Fly	1	0	0	0	0	0	0	1
592	Fly	1	0	0	0	0	0	0	1
593	Fly	1	0	0	0	0	0	0	1
594	Mammal	1	0	1	0	0	0	0	0
595	Mammal	1	0	1	0	0	0	0	0
596	Mammal	1	0	1	0	0	0	0	0
597	Mammal	1	0	1	0	0	0	0	0
598	Mammal	1	0	1	0	0	0	0	0
599	Mammal	1	0	1	0	0	0	0	0
600	Mammal	1	0	1	0	0	0	0	0
601	Mammal	1	0	1	0	0	0	0	0
602	Mammal	1	0	1	0	0	0	0	0
603	Mammal	1	0	0	0	0	1	0	0
604	Mammal	1	0	0	0	0	1	0	0
605	Mammal	1	0	0	0	0	1	0	0
606	Mammal	1	0	0	0	0	1	0	0
607	Mammal	1	0	0	0	0	1	0	0
608	Mammal	1	0	0	0	0	1	0	0
609	Mammal	1	0	0	0	0	1	0	0
610	Mammal	1	0	0	0	0	1	0	0
611	Mammal	1	0	0	0	0	1	0	0
612	Mammal	1	0	0	0	0	0	1	0
613	Mammal	1	0	0	0	0	0	1	0
614	Mammal	1	0	0	0	0	0	1	0
615	Mammal	1	0	0	0	0	0	1	0
616	Mammal	1	0	0	0	0	0	1	0
617	Mammal	1	0	0	0	0	0	1	0
618	Mammal	1	0	0	0	0	0	1	0
619	Mammal	1	0	0	0	0	0	1	0
620	Mammal	1	0	0	0	0	0	1	0
621	Mammal	1	0	1	0	0	0	0	0
622	Mammal	1	0	1	0	0	0	0	0

Appendix 2

Idealized Trait Combinations		Color Brightness	Color						
Number	Pollination Syndrome	Vivid	Brown	White	Red	Green	Yellow	Blue	Purple
584	Fly	0	0	0	0	0	1	0	0
585	Fly	0	0	0	0	0	1	0	0
586	Fly	0	0	0	0	0	1	0	0
587	Fly	0	0	0	0	0	1	0	0
588	Fly	0	0	0	0	0	1	0	0
589	Fly	0	0	0	0	0	1	0	0
590	Fly	0	0	0	0	0	1	0	0
591	Fly	0	0	0	0	0	1	0	0
592	Fly	0	0	0	0	0	1	0	0
593	Fly	0	0	0	0	0	1	0	0
594	Mammal	0	1	0	0	0	0	0	0
595	Mammal	0	1	0	0	0	0	0	0
596	Mammal	0	1	0	0	0	0	0	0
597	Mammal	0	1	0	0	0	0	0	0
598	Mammal	0	1	0	0	0	0	0	0
599	Mammal	0	1	0	0	0	0	0	0
600	Mammal	0	1	0	0	0	0	0	0
601	Mammal	0	1	0	0	0	0	0	0
602	Mammal	0	1	0	0	0	0	0	0
603	Mammal	0	1	0	0	0	0	0	0
604	Mammal	0	1	0	0	0	0	0	0
605	Mammal	0	1	0	0	0	0	0	0
606	Mammal	0	1	0	0	0	0	0	0
607	Mammal	0	1	0	0	0	0	0	0
608	Mammal	0	1	0	0	0	0	0	0
609	Mammal	0	1	0	0	0	0	0	0
610	Mammal	0	1	0	0	0	0	0	0
611	Mammal	0	1	0	0	0	0	0	0
612	Mammal	0	1	0	0	0	0	0	0
613	Mammal	0	1	0	0	0	0	0	0
614	Mammal	0	1	0	0	0	0	0	0
615	Mammal	0	1	0	0	0	0	0	0
616	Mammal	0	1	0	0	0	0	0	0
617	Mammal	0	1	0	0	0	0	0	0
618	Mammal	0	1	0	0	0	0	0	0
619	Mammal	0	1	0	0	0	0	0	0
620	Mammal	0	1	0	0	0	0	0	0
621	Mammal	0	0	1	0	0	0	0	0
622	Mammal	0	0	1	0	0	0	0	0

Appendix 2

Idealized Trait Combinations		Flower Shape							Size	
Number	Pollination Syndrome	Trap	Open	Bell	Brush	Gullet	Flag	Tube	Medium/ Small	Mechanically Strong
623	Mammal	0	0	0	1	0	0	0	0	1
624	Mammal	0	1	0	0	0	0	0	0	1
625	Mammal	0	0	1	0	0	0	0	0	1
626	Mammal	0	0	0	1	0	0	0	0	1
627	Mammal	0	1	0	0	0	0	0	0	1
628	Mammal	0	0	1	0	0	0	0	0	1
629	Mammal	0	0	0	1	0	0	0	0	1
630	Mammal	0	1	0	0	0	0	0	0	1
631	Mammal	0	0	1	0	0	0	0	0	1
632	Mammal	0	0	0	1	0	0	0	0	1
633	Mammal	0	1	0	0	0	0	0	0	1
634	Mammal	0	0	1	0	0	0	0	0	1
635	Mammal	0	0	0	1	0	0	0	0	1
636	Mammal	0	1	0	0	0	0	0	0	1
637	Mammal	0	0	1	0	0	0	0	0	1
638	Mammal	0	0	0	1	0	0	0	0	1
639	Mammal	0	1	0	0	0	0	0	0	1
640	Mammal	0	0	1	0	0	0	0	0	1
641	Mammal	0	0	0	1	0	0	0	0	1
642	Mammal	0	1	0	0	0	0	0	0	1
643	Mammal	0	0	1	0	0	0	0	0	1
644	Mammal	0	0	0	1	0	0	0	0	1
645	Mammal	0	1	0	0	0	0	0	0	1
646	Mammal	0	0	1	0	0	0	0	0	1
647	Mammal	0	0	0	1	0	0	0	0	1
648	Mammal	0	1	0	0	0	0	0	0	1
649	Mammal	0	0	1	0	0	0	0	0	1
650	Mammal	0	0	0	1	0	0	0	0	1
651	Mammal	0	1	0	0	0	0	0	0	1
652	Mammal	0	0	1	0	0	0	0	0	1
653	Mammal	0	0	0	1	0	0	0	0	1
654	Mammal	0	1	0	0	0	0	0	0	1
655	Mammal	0	0	1	0	0	0	0	0	1
656	Mammal	0	0	0	1	0	0	0	0	1
657	Mammal	0	1	0	0	0	0	0	0	1
658	Mammal	0	0	1	0	0	0	0	0	1
659	Mammal	0	0	0	1	0	0	0	0	1
660	Mammal	0	1	0	0	0	0	0	0	1
661	Mammal	0	0	1	0	0	0	0	0	1

Appendix 2

Idealized Trait Combinations		Symmetry	Anthers		Flower Orientation		
Number	Pollination Syndrome	Zygomorphic	Stiff	Exposed	Pendant	Upright	Horizontal
623	Mammal	0	1	1	1	0	0
624	Mammal	0	1	1	0	1	0
625	Mammal	0	1	1	0	1	0
626	Mammal	0	1	1	0	1	0
627	Mammal	0	1	1	0	0	1
628	Mammal	0	1	1	0	0	1
629	Mammal	0	1	1	0	0	1
630	Mammal	0	1	1	1	0	0
631	Mammal	0	1	1	1	0	0
632	Mammal	0	1	1	1	0	0
633	Mammal	0	1	1	0	1	0
634	Mammal	0	1	1	0	1	0
635	Mammal	0	1	1	0	1	0
636	Mammal	0	1	1	0	0	1
637	Mammal	0	1	1	0	0	1
638	Mammal	0	1	1	0	0	1
639	Mammal	0	1	1	1	0	0
640	Mammal	0	1	1	1	0	0
641	Mammal	0	1	1	1	0	0
642	Mammal	0	1	1	0	1	0
643	Mammal	0	1	1	0	1	0
644	Mammal	0	1	1	0	1	0
645	Mammal	0	1	1	0	0	1
646	Mammal	0	1	1	0	0	1
647	Mammal	0	1	1	0	0	1
648	Mammal	0	1	1	1	0	0
649	Mammal	0	1	1	1	0	0
650	Mammal	0	1	1	1	0	0
651	Mammal	0	1	1	0	1	0
652	Mammal	0	1	1	0	1	0
653	Mammal	0	1	1	0	1	0
654	Mammal	0	1	1	0	0	1
655	Mammal	0	1	1	0	0	1
656	Mammal	0	1	1	0	0	1
657	Mammal	0	1	1	1	0	0
658	Mammal	0	1	1	1	0	0
659	Mammal	0	1	1	1	0	0
660	Mammal	0	1	1	0	1	0
661	Mammal	0	1	1	0	1	0

Appendix 2

Idealized Trait Combinations		Tube Morphology				Time of Opening	Nectar		Nectar Volume	
Number	Pollination Syndrome	Narrow	Wide	Short	Long	Day	Guides	Present	Abundant	Moderate
623	Mammal	0	0	0	0	0	0	1	1	0
624	Mammal	0	0	0	0	0	0	1	1	0
625	Mammal	0	0	0	0	0	0	1	1	0
626	Mammal	0	0	0	0	0	0	1	1	0
627	Mammal	0	0	0	0	0	0	1	1	0
628	Mammal	0	0	0	0	0	0	1	1	0
629	Mammal	0	0	0	0	0	0	1	1	0
630	Mammal	0	0	0	0	0	0	1	1	0
631	Mammal	0	0	0	0	0	0	1	1	0
632	Mammal	0	0	0	0	0	0	1	1	0
633	Mammal	0	0	0	0	0	0	1	1	0
634	Mammal	0	0	0	0	0	0	1	1	0
635	Mammal	0	0	0	0	0	0	1	1	0
636	Mammal	0	0	0	0	0	0	1	1	0
637	Mammal	0	0	0	0	0	0	1	1	0
638	Mammal	0	0	0	0	0	0	1	1	0
639	Mammal	0	0	0	0	0	0	1	1	0
640	Mammal	0	0	0	0	0	0	1	1	0
641	Mammal	0	0	0	0	0	0	1	1	0
642	Mammal	0	0	0	0	0	0	1	1	0
643	Mammal	0	0	0	0	0	0	1	1	0
644	Mammal	0	0	0	0	0	0	1	1	0
645	Mammal	0	0	0	0	0	0	1	1	0
646	Mammal	0	0	0	0	0	0	1	1	0
647	Mammal	0	0	0	0	0	0	1	1	0
648	Mammal	0	0	0	0	0	0	1	1	0
649	Mammal	0	0	0	0	0	0	1	1	0
650	Mammal	0	0	0	0	0	0	1	1	0
651	Mammal	0	0	0	0	0	0	1	1	0
652	Mammal	0	0	0	0	0	0	1	1	0
653	Mammal	0	0	0	0	0	0	1	1	0
654	Mammal	0	0	0	0	0	0	1	1	0
655	Mammal	0	0	0	0	0	0	1	1	0
656	Mammal	0	0	0	0	0	0	1	1	0
657	Mammal	0	0	0	0	0	0	1	1	0
658	Mammal	0	0	0	0	0	0	1	1	0
659	Mammal	0	0	0	0	0	0	1	1	0
660	Mammal	0	0	0	0	0	0	1	1	0
661	Mammal	0	0	0	0	0	0	1	1	0

Appendix 2

Idealized Trait Combinations		Odor Strength		Scent Type					
Number	Pollination Syndrome	Strong	None	Sweet	Fruity	Fresh	Musky	Sour	Decaying
623	Mammal	1	0	1	0	0	0	0	0
624	Mammal	1	0	1	0	0	0	0	0
625	Mammal	1	0	1	0	0	0	0	0
626	Mammal	1	0	1	0	0	0	0	0
627	Mammal	1	0	1	0	0	0	0	0
628	Mammal	1	0	1	0	0	0	0	0
629	Mammal	1	0	1	0	0	0	0	0
630	Mammal	1	0	0	0	0	1	0	0
631	Mammal	1	0	0	0	0	1	0	0
632	Mammal	1	0	0	0	0	1	0	0
633	Mammal	1	0	0	0	0	1	0	0
634	Mammal	1	0	0	0	0	1	0	0
635	Mammal	1	0	0	0	0	1	0	0
636	Mammal	1	0	0	0	0	1	0	0
637	Mammal	1	0	0	0	0	1	0	0
638	Mammal	1	0	0	0	0	1	0	0
639	Mammal	1	0	0	0	0	0	1	0
640	Mammal	1	0	0	0	0	0	1	0
641	Mammal	1	0	0	0	0	0	1	0
642	Mammal	1	0	0	0	0	0	1	0
643	Mammal	1	0	0	0	0	0	1	0
644	Mammal	1	0	0	0	0	0	1	0
645	Mammal	1	0	0	0	0	0	1	0
646	Mammal	1	0	0	0	0	0	1	0
647	Mammal	1	0	0	0	0	0	1	0
648	Mammal	1	0	1	0	0	0	0	0
649	Mammal	1	0	1	0	0	0	0	0
650	Mammal	1	0	1	0	0	0	0	0
651	Mammal	1	0	1	0	0	0	0	0
652	Mammal	1	0	1	0	0	0	0	0
653	Mammal	1	0	1	0	0	0	0	0
654	Mammal	1	0	1	0	0	0	0	0
655	Mammal	1	0	1	0	0	0	0	0
656	Mammal	1	0	1	0	0	0	0	0
657	Mammal	1	0	0	0	0	1	0	0
658	Mammal	1	0	0	0	0	1	0	0
659	Mammal	1	0	0	0	0	1	0	0
660	Mammal	1	0	0	0	0	1	0	0
661	Mammal	1	0	0	0	0	1	0	0

Appendix 2

Idealized Trait Combinations		Color Brightness	Color						
Number	Pollination Syndrome	Vivid	Brown	White	Red	Green	Yellow	Blue	Purple
623	Mammal	0	0	1	0	0	0	0	0
624	Mammal	0	0	1	0	0	0	0	0
625	Mammal	0	0	1	0	0	0	0	0
626	Mammal	0	0	1	0	0	0	0	0
627	Mammal	0	0	1	0	0	0	0	0
628	Mammal	0	0	1	0	0	0	0	0
629	Mammal	0	0	1	0	0	0	0	0
630	Mammal	0	0	1	0	0	0	0	0
631	Mammal	0	0	1	0	0	0	0	0
632	Mammal	0	0	1	0	0	0	0	0
633	Mammal	0	0	1	0	0	0	0	0
634	Mammal	0	0	1	0	0	0	0	0
635	Mammal	0	0	1	0	0	0	0	0
636	Mammal	0	0	1	0	0	0	0	0
637	Mammal	0	0	1	0	0	0	0	0
638	Mammal	0	0	1	0	0	0	0	0
639	Mammal	0	0	1	0	0	0	0	0
640	Mammal	0	0	1	0	0	0	0	0
641	Mammal	0	0	1	0	0	0	0	0
642	Mammal	0	0	1	0	0	0	0	0
643	Mammal	0	0	1	0	0	0	0	0
644	Mammal	0	0	1	0	0	0	0	0
645	Mammal	0	0	1	0	0	0	0	0
646	Mammal	0	0	1	0	0	0	0	0
647	Mammal	0	0	1	0	0	0	0	0
648	Mammal	0	0	0	0	1	0	0	0
649	Mammal	0	0	0	0	1	0	0	0
650	Mammal	0	0	0	0	1	0	0	0
651	Mammal	0	0	0	0	1	0	0	0
652	Mammal	0	0	0	0	1	0	0	0
653	Mammal	0	0	0	0	1	0	0	0
654	Mammal	0	0	0	0	1	0	0	0
655	Mammal	0	0	0	0	1	0	0	0
656	Mammal	0	0	0	0	1	0	0	0
657	Mammal	0	0	0	0	1	0	0	0
658	Mammal	0	0	0	0	1	0	0	0
659	Mammal	0	0	0	0	1	0	0	0
660	Mammal	0	0	0	0	1	0	0	0
661	Mammal	0	0	0	0	1	0	0	0

Appendix 2

Idealized Trait Combinations		Flower Shape							Size	
Number	Pollination Syndrome	Trap	Open	Bell	Brush	Gullet	Flag	Tube	Medium/ Small	Mechanically Strong
662	Mammal	0	0	0	1	0	0	0	0	1
663	Mammal	0	1	0	0	0	0	0	0	1
664	Mammal	0	0	1	0	0	0	0	0	1
665	Mammal	0	0	0	1	0	0	0	0	1
666	Mammal	0	1	0	0	0	0	0	0	1
667	Mammal	0	0	1	0	0	0	0	0	1
668	Mammal	0	0	0	1	0	0	0	0	1
669	Mammal	0	1	0	0	0	0	0	0	1
670	Mammal	0	0	1	0	0	0	0	0	1
671	Mammal	0	0	0	1	0	0	0	0	1
672	Mammal	0	1	0	0	0	0	0	0	1
673	Mammal	0	0	1	0	0	0	0	0	1
674	Mammal	0	0	0	1	0	0	0	0	1
675	Wasp	0	1	0	0	0	0	0	1	0
676	Wasp	0	0	1	0	0	0	0	1	0
677	Wasp	0	0	0	0	0	0	1	1	0
678	Wasp	0	1	0	0	0	0	0	1	0
679	Wasp	0	0	1	0	0	0	0	1	0
680	Wasp	0	0	0	0	0	0	1	1	0
681	Wasp	0	1	0	0	0	0	0	1	0
682	Wasp	0	0	1	0	0	0	0	1	0
683	Wasp	0	0	0	0	0	0	1	1	0
684	Wasp	0	1	0	0	0	0	0	1	0
685	Wasp	0	0	1	0	0	0	0	1	0
686	Wasp	0	0	0	0	0	0	1	1	0

Appendix 2

Idealized Trait Combinations		Symmetry	Anthers		Flower Orientation		
Number	Pollination Syndrome	Zygomorphic	Stiff	Exposed	Pendant	Upright	Horizontal
662	Mammal	0	1	1	0	1	0
663	Mammal	0	1	1	0	0	1
664	Mammal	0	1	1	0	0	1
665	Mammal	0	1	1	0	0	1
666	Mammal	0	1	1	1	0	0
667	Mammal	0	1	1	1	0	0
668	Mammal	0	1	1	1	0	0
669	Mammal	0	1	1	0	1	0
670	Mammal	0	1	1	0	1	0
671	Mammal	0	1	1	0	1	0
672	Mammal	0	1	1	0	0	1
673	Mammal	0	1	1	0	0	1
674	Mammal	0	1	1	0	0	1
675	Wasp	1	1	0	1	0	0
676	Wasp	1	1	0	1	0	0
677	Wasp	1	1	0	1	0	0
678	Wasp	1	1	0	1	0	0
679	Wasp	1	1	0	1	0	0
680	Wasp	1	1	0	1	0	0
681	Wasp	1	1	0	1	0	0
682	Wasp	1	1	0	1	0	0
683	Wasp	1	1	0	1	0	0
684	Wasp	1	1	0	1	0	0
685	Wasp	1	1	0	1	0	0
686	Wasp	1	1	0	1	0	0

Appendix 2

Idealized Trait Combinations		Tube Morphology				Time of Opening	Nectar		Nectar Volume	
Number	Pollination Syndrome	Narrow	Wide	Short	Long	Day	Guides	Present	Abundant	Moderate
662	Mammal	0	0	0	0	0	0	1	1	0
663	Mammal	0	0	0	0	0	0	1	1	0
664	Mammal	0	0	0	0	0	0	1	1	0
665	Mammal	0	0	0	0	0	0	1	1	0
666	Mammal	0	0	0	0	0	0	1	1	0
667	Mammal	0	0	0	0	0	0	1	1	0
668	Mammal	0	0	0	0	0	0	1	1	0
669	Mammal	0	0	0	0	0	0	1	1	0
670	Mammal	0	0	0	0	0	0	1	1	0
671	Mammal	0	0	0	0	0	0	1	1	0
672	Mammal	0	0	0	0	0	0	1	1	0
673	Mammal	0	0	0	0	0	0	1	1	0
674	Mammal	0	0	0	0	0	0	1	1	0
675	Wasp	0	1	1	0	1	0	1	0	1
676	Wasp	0	1	1	0	1	0	1	0	1
677	Wasp	0	1	1	0	1	0	1	0	1
678	Wasp	0	1	1	0	1	0	1	0	1
679	Wasp	0	1	1	0	1	0	1	0	1
680	Wasp	0	1	1	0	1	0	1	0	1
681	Wasp	0	1	1	0	1	0	1	0	0
682	Wasp	0	1	1	0	1	0	1	0	0
683	Wasp	0	1	1	0	1	0	1	0	0
684	Wasp	0	1	1	0	1	0	1	0	0
685	Wasp	0	1	1	0	1	0	1	0	0
686	Wasp	0	1	1	0	1	0	1	0	0

Appendix 2

Idealized Trait Combinations		Odor Strength		Scent Type					
Number	Pollination Syndrome	Strong	None	Sweet	Fruity	Fresh	Musky	Sour	Decaying
662	Mammal	1	0	0	0	0	1	0	0
663	Mammal	1	0	0	0	0	1	0	0
664	Mammal	1	0	0	0	0	1	0	0
665	Mammal	1	0	0	0	0	1	0	0
666	Mammal	1	0	0	0	0	0	1	0
667	Mammal	1	0	0	0	0	0	1	0
668	Mammal	1	0	0	0	0	0	1	0
669	Mammal	1	0	0	0	0	0	1	0
670	Mammal	1	0	0	0	0	0	1	0
671	Mammal	1	0	0	0	0	0	1	0
672	Mammal	1	0	0	0	0	0	1	0
673	Mammal	1	0	0	0	0	0	1	0
674	Mammal	1	0	0	0	0	0	1	0
675	Wasp	1	0	0	0	0	0	1	0
676	Wasp	1	0	0	0	0	0	1	0
677	Wasp	1	0	0	0	0	0	1	0
678	Wasp	1	0	0	0	0	0	1	0
679	Wasp	1	0	0	0	0	0	1	0
680	Wasp	1	0	0	0	0	0	1	0
681	Wasp	1	0	0	0	0	0	1	0
682	Wasp	1	0	0	0	0	0	1	0
683	Wasp	1	0	0	0	0	0	1	0
684	Wasp	1	0	0	0	0	0	1	0
685	Wasp	1	0	0	0	0	0	1	0
686	Wasp	1	0	0	0	0	0	1	0

Appendix 2

Idealized Trait Combinations		Color Brightness	Color						
Number	Pollination Syndrome	Vivid	Brown	White	Red	Green	Yellow	Blue	Purple
662	Mammal	0	0	0	0	1	0	0	0
663	Mammal	0	0	0	0	1	0	0	0
664	Mammal	0	0	0	0	1	0	0	0
665	Mammal	0	0	0	0	1	0	0	0
666	Mammal	0	0	0	0	1	0	0	0
667	Mammal	0	0	0	0	1	0	0	0
668	Mammal	0	0	0	0	1	0	0	0
669	Mammal	0	0	0	0	1	0	0	0
670	Mammal	0	0	0	0	1	0	0	0
671	Mammal	0	0	0	0	1	0	0	0
672	Mammal	0	0	0	0	1	0	0	0
673	Mammal	0	0	0	0	1	0	0	0
674	Mammal	0	0	0	0	1	0	0	0
675	Wasp	0	1	0	0	0	0	0	0
676	Wasp	0	1	0	0	0	0	0	0
677	Wasp	0	1	0	0	0	0	0	0
678	Wasp	0	0	0	0	0	0	0	1
679	Wasp	0	0	0	0	0	0	0	1
680	Wasp	0	0	0	0	0	0	0	1
681	Wasp	0	1	0	0	0	0	0	0
682	Wasp	0	1	0	0	0	0	0	0
683	Wasp	0	1	0	0	0	0	0	0
684	Wasp	0	0	0	0	0	0	0	1
685	Wasp	0	0	0	0	0	0	0	1
686	Wasp	0	0	0	0	0	0	0	1