The Biology of Yadon's Piperia
Implications for Species Conservation and Management


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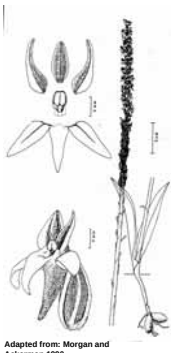
Overview:

- **Life cycle**
- **Reproductive biology**
  - **Pollination ecology**
  - **Breeding system**
  - **Seed ecology**

Yadon's piperia (*Piperia yadonii*)


Adapted from: Morgan and Ackerman 1990


Ronald Coleman (RC)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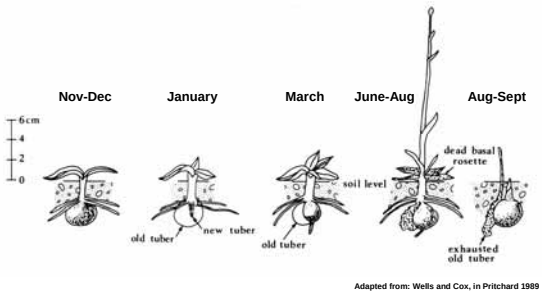
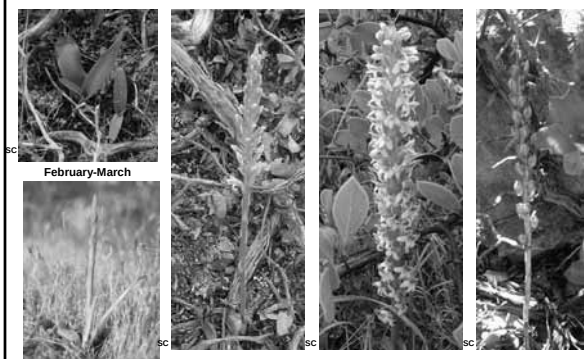
Life cycle of Yadon's piperia: A perennial geophyte growing from a tuber



Adapted from: Wells and Cox, in Pritchard 1989

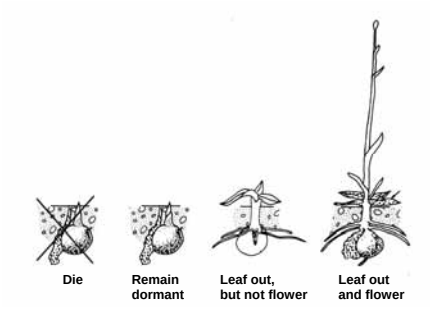
A year in the life of Yadon's piperia



What's a tuber to do?

- Not all tubers leaf out every year. Dormancy!
  - In similar species, tubers can remain dormant for 1 to 4 years before re-emerging (Rasmussen 1995).
  - The proportion of tubers that remain dormant each year can be assumed to fluctuate, but we don't know how much.
- Not all tubers that leaf out in a given year will flower.
  - Estimates in several populations have shown that 0.4% to 22% of individuals that leaf out will also flower in any given year. It can fluctuate wildly.

In any given year a tuber can do one of four things



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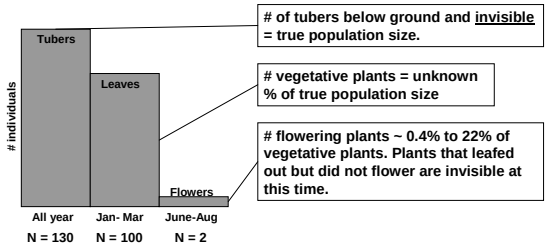
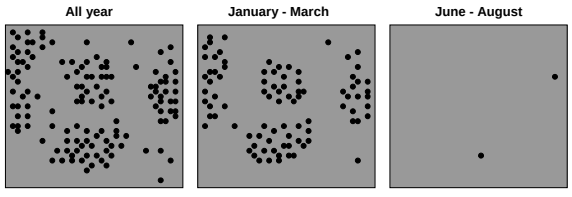
Which numbers would you choose for a population estimate?



Hypothetical population

Which distribution is most accurate?



# tubers below ground and invisible = "true" population size	# vegetative plants = unknown % of true population size	# flowering plants ~ 0.4% to 22% of vegetative plants
N = 130	N = 100	N = 2

Estimates of population size and trends – moving beyond counts of vegetative or flowering individuals

- Mark-recapture methods – estimating population size and trends using methods designed for animals. Relies on estimating dormancy rates.
  - Limitation: Need to mark individuals and this has proven difficult for Yadon's piperia due to high density. More effort should be made in this regard. Very time-consuming.
- Presence/absence – using frequency analysis to assess trends, but not population size.

What about seedlings?

- Orchid seeds germinate and develop into protocorms which remain underground for years (often 2 – 4) before developing into tubers that sprout leaves (Rasmussen and Whigham 1998; Wells 1980).
- Seeds are short-lived – no seed bank.

Protocorm and rhizoids

Life cycle: Implications for conservation and management

1. Estimating population size, trends, and distribution becomes a real challenge!
   - Monitoring for population size and distribution will take 1 year: identify during flowering, go back following year to estimate vegetative individuals and map distribution.
   - A more realistic estimate of population size can only be arrived at over a number of years of repeat censusing of vegetative plants.
   - Presence/absence or mark-recapture methods may be able to identify population trends.

Reproductive Biology of Yadon's piperia

- Pollination ecology
- Breeding system
- Seed ecology

Pollinators and plant conservation

- If an endangered plant species depends on pollen transfer by an animal for reproduction, healthy populations of that animal(s) need to be managed for.
- It becomes very important to know if a plant depends on a specialized or rare pollinator for reproduction. Orchids are renowned for pollinator specialization.
- Is low pollinator service limiting reproductive output? If so, why is pollinator service low?

Pollination syndrome of Yadon's piperia

Phalaenophily = moth pollination syndrome:

Flowers pale-colored

Flower spurred, spur collects nectar

Flowers become fragrant at dusk

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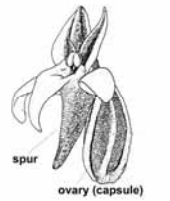
Piperia yadonii flower



Adapted from: Morgan and Ackerman 1990

Floral visitors of Yadon's piperia

Predominantly night-flying, short-tongued moths (Pyralidae, Geometridae, Noctuidae, Pterophoridae) that are most active between 9:00pm - 12:00am.

- 14 spp. total, 2 remain unidentified.
- 9 spp. known to be common or very common, 5 no information.
- 6 spp. carrying pollen – 4 of these very common, 2 no information.

*Udea profundalis**

*Agrotis ipsilon**

Hydriomena nubilofasciata

Nomophila nearctica

* = found carrying orchid pollen

From Powell and Hogue 1979

Moth larval host plants

Generalists:

***Agrotis ipsilon*: generalists on low growing succulent plants, crop pest.**

***Udea profundalis*: generalists on soft-leaved herbs and shrubs, crop pest.**

***Nomophila nearctica*: low-growing plants, mostly grasses, clover.**

Specialists:

***Prochoerodes truxaliata*: *Baccharis pilularis,* may be a generalist.**

***Elpiste marcescaria*: *Baccharis pilularis*.**

***Drepanulatrix baueraria*: *Ceanothus* (probably *C. thyrsiflorus*).**

***Hydriomena nubilofasciata*: *Quercus agrifolia*.**

***Pyrausta perrubralis*: probably a mint (Lamiaceae).**

* = found carrying orchid pollen

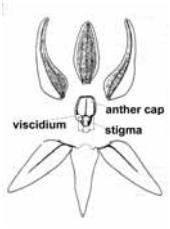
From Powell and Hogue 1979 and pers. comm. Jerry Powell.

Other floral visitors of Yadon's piperia

Mosquitoes – one found carrying pollen.

Bumblebees (*Bombus* spp.) – rarely observed (2), but one found carrying pollen. May be important pollinators in some populations.

Pollination mechanism



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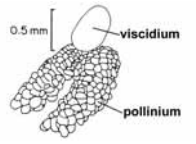
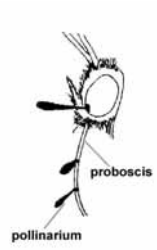
***Piperia yadonii* flower**



Adapted from: Ackerman 1977

***Piperia* sp. pollinarium: two per flower**



Adapted from: Carling & Catling 1991

Moth

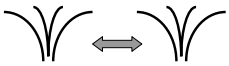
Pollination biology: Implications for conservation and management

1. **Pollinators are required for reproduction, so managing for pollinators is important.**
2. **Floral visitors observed carrying pollen belong to multiple species and most are common and w/o special needs. So management should not be too difficult.**
   - **No pesticides close to piperia, maintain local floristic diversity (alternative nectar sources for adults and host plants for larvae).**
3. **Maintentance of large populations of flowering individuals is advisable in order to attract pollinators.**

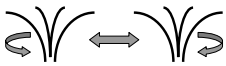
Breeding system

Breeding system = mating strategy. Does Yadon's piperia produce seeds by self pollination, outcross pollination, or a combination of the two?

Selfing: pollen flows between or within flowers on the same plant



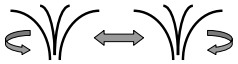
Outcrossing: pollen flows between flowers on different plants



Mixed mating: a plant can outcross and self

Breeding system – Why do we care?

Say you have a species with a mixed mating strategy that predominantly outcrosses. If selfing rate increases, that species might be vulnerable to inbreeding depression.



Inbreeding = mating with self or between close relatives.

Inbreeding depression = lower reproductive success and/or survivorship of offspring due to inbreeding.

What might cause an increase in selfing rates?

- **Reduced access to mates following a reduction in population size: population decline, extirpation by humans.**

Breeding system experiment

Breeding system tested for	Treatment
Outcrossing	Caged, emasculated, outcrossed
Selfing with pollen transfer	Caged, selfed
Selfing without pollen transfer**	Caged, unmanipulated
Agamospermy (seeds w/o sex)	Caged, emasculated

(*n* = 20 plants in each of 2 populations, 4 flowers/plant/treatment)

** = this treatment determines whether pollinator transfer of pollen is required for seed set.

Breeding system experiment

Outcome measures:

FF = fruits/flowers

VSF = proportion viable seeds/fruit

Orchid seeds

Two populations:

Area K: ~ 5931 vegetative individuals, 10.6 acres
Monterey pine forest (Del Monte Forest Foundation)

Manzanita Park: ~ 3080 vegetative individuals, 450 acres
Maritime chaparral (Monterey County Parks)

Breeding system experiment results

1. Pollen transfer by a pollinator is required for seed set, even for self-fertilization.
2. Flowers do not make seeds asexually.

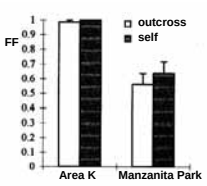
Breeding system tested for	VSF	Population
Selfing without pollen transfer	0	Area K
	0.008	Manzanita Park
Agamospermy (seeds w/o sex)	0	Area K
	0	Manzanita Park

VSF = proportion viable seeds/fruit

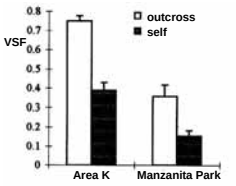
3. Yadon's piperia has a mixed mating strategy…..

Breeding system experiment results

4. Outcross and self pollinations did not differ in terms of fruit set: no evidence for inbreeding depression.
5. Self pollinations produced significantly less viable seeds/fruit than did outcross pollinations: evidence for inbreeding depression.
   - Area K: 47% reduction
   - Manzanita Park: 60% reduction



FF = fruits/flower



VSF = prop. viable seeds/fruit $p < 0.001$

Breeding system: Implications for conservation and management

1. It is advisable to manage for the maintenance of outcrossing.
   - Maintain large populations.
   - Maintain connectivity between populations in terms of gene flow (pollen and seeds).
2. In order to really know the kind of threat inbreeding depression poses, we need to know selfing rates and potential inbreeding depression in many populations of differing sizes and degree of isolation.

Seed ecology: Requirements for germination and establishment of orchid seeds

- **Orchid seeds require a mycorrhizal symbiont in order to establish. Often a number of fungal strains can work.**
- **Adults of some species require yearly mycorrhizal associations in annual roots or tubers.**

Implications of mycorrhizal associations for conservation and management

1. **The distribution of Yadon's piperia will correlate with the distribution of symbiotic mycorrhizae.**
2. **Propagation by seeds must involve the use of symbiotic fungi.**
3. **Implications for transplantation of seedlings and/or tubers to unoccupied sites?**

Conclusions

1. **Developing a way to test for population trends should be a priority.**
2. **Population estimates and distribution maps should be made using vegetative individuals and repeat censuses.**
3. **Pollinators must be managed for.**
4. **Propagation of any sort must consider mycorrhizal associations.**

Conclusions

5. **Managing for large populations is advisable:**
   - **To attract required pollinators.**
   - **To encourage outcrossing given evidence of inbreeding depression.**
   - **To reduce effects of catastrophic events (e.g. reproductive failure).**
6. **Maintain connectivity between populations to encourage gene flow given evidence of inbreeding depression.**

Acknowledgements

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Rocky Creek Ridge, Big Sur

Prunedale Hills

Pesante Ridge, Prunedale

Some baseline fecundity data

- Proportional fruit set (fruits/flowers) is within the range of other N. American orchid species that offer nectar.
  - Yadon's piperia: 21% (1999, 6 pops) and 46% (2000, 4 pops).
  - 11 spp. nectariferous orchids in N. America: 49% (range 13.6% to 79%) (Neiland and Wilcock 1998).
- Viable seeds/fruit (*n* = 20 plants, each pop, 4 flrs/plant):
  - 0.19 at Manzanita Park
  - 0.50 at Area K
- Typical % flowering plants that set fruit in Yadon's piperia: 58% (1999, 7 pops) and 73% (2000, 4 pops).
  - Manzanita Park, 2003: the proportion of flowering plants that set fruit was 5%! Reproductive failure, unknown cause.

Gaps in our knowledge

- Population trends.
- Effects of small population size on vital rates.
- Ecological requirements of seedlings and adults:
  - Regeneration niche
  - Factors affecting fecundity
  - What accounts for the fine-scale distribution of piperia?
- Why do chaparral plants appear to have lower fecundity compared to pine forest plants?
- Population genetic structure.