



“Nothing in biology makes sense except in the light of evolution”

Theodosius Dobzhansky
(1900-1975)

Fruit fly geneticist and
founder of the modern
evolutionary synthesis

Organismal reproductive diversity



E. coli



Chimpanzee



Hydra



Passion flower

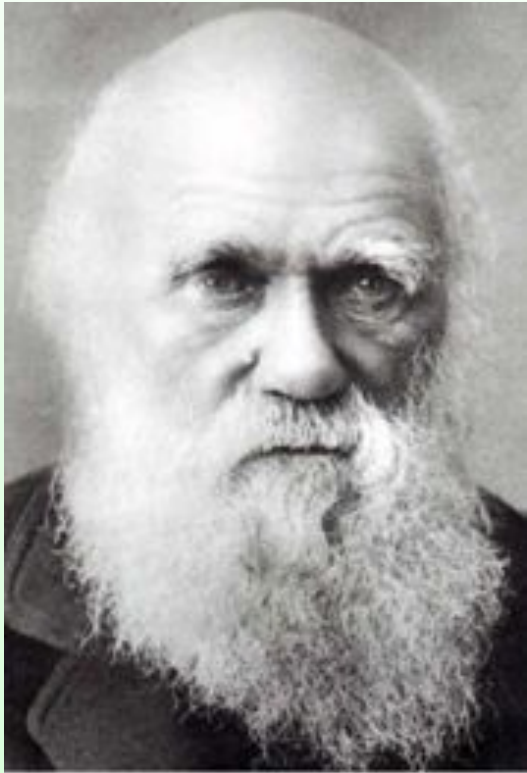


Fungi



Peacock

Darwin on sex



“We do not even in the least know the final cause of sexuality ... why new beings should be produced by the union of the two sexual elements, instead of by a process of parthenogenesis... The whole subject is as yet hidden in darkness”

Darwin 1862

Sex, Reproductive Systems and Evolution

- 1. Why did sex evolve?**
- 2. How do we explain the diversity of reproductive systems?**
- 3. What are the costs and benefits of inbreeding & outbreeding?**

Reproductive Modes

Reproductive system

asexual

sexual

Sexual system

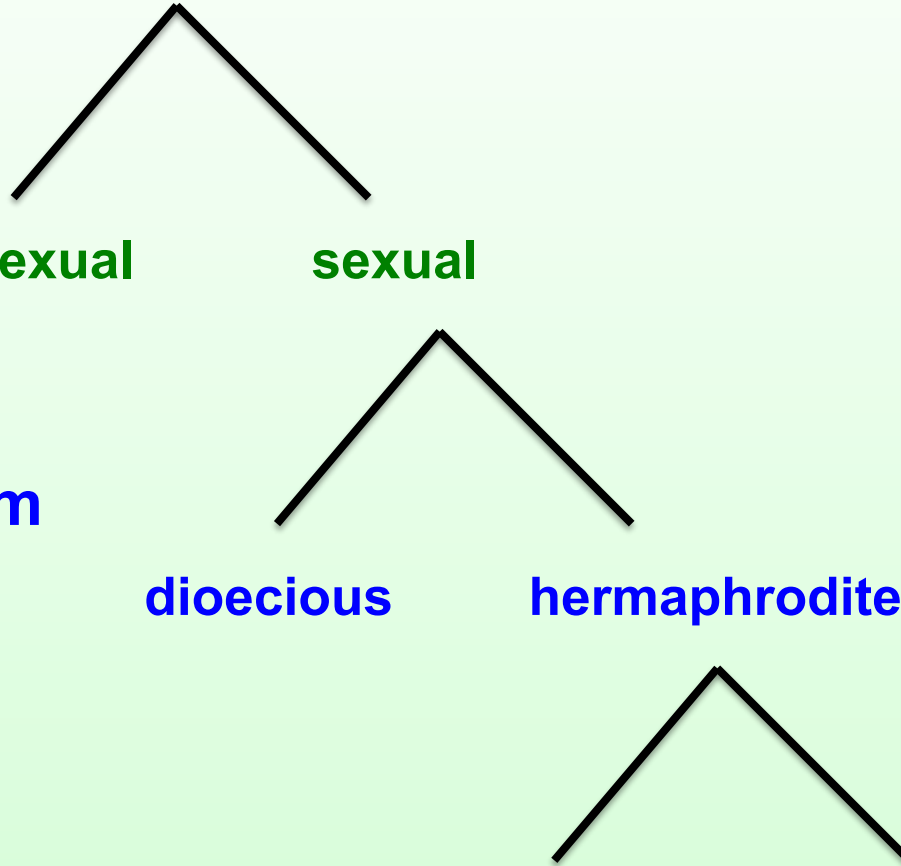
dioecious

hermaphrodite

Mating system

cross-fertilization

self-fertilization



Most flowering plants are hermaphroditic

Female

Male

Lilium humboldtii



Plant Sex Made Easy

- **Why should we care about plant sex?**
- **Fundamentals of plant sexual diversity**
- **Darwinian perspectives**
- **Evolutionary transitions**
- **In search of novel sexual diversity**

Amazonia, South Africa, China

Why should we care about plant sex?

- **Plant breeding, crop production and world food**
- **Biotechnology and GMO' s**
 - Escape of genes and “genetic pollution”
- **Plant invasion biology**
- **Conservation biology**

Some terms in plant reproduction

- **reproductive system** – the mode or type of reproduction
- **pollination** – the transfer of pollen from male to female sex organs
- **mating (or fertilization)** – the fusion of male and female gametes to form a seed

Distinctive features of flowering plants influencing their reproduction

- * Immobility
- * hermaphroditism (bisexuality)*
- * multiple reproductive structures
- * clonality

90% of the 300,000 species of flowering plants

Pollination Systems in Plants

- animal-pollination
- wind-pollination
- water-pollination
- self-pollination

Some animal groups that pollinate flowers

- Bee
- Fly
- Butterfly
- Moth
- Beetle
- Bird
- Bat
- Ant*
- Rodent*
- Lizard*

* Uncommon to rare

Stinky flowers of *Amorphophallus* - what pollinates them?



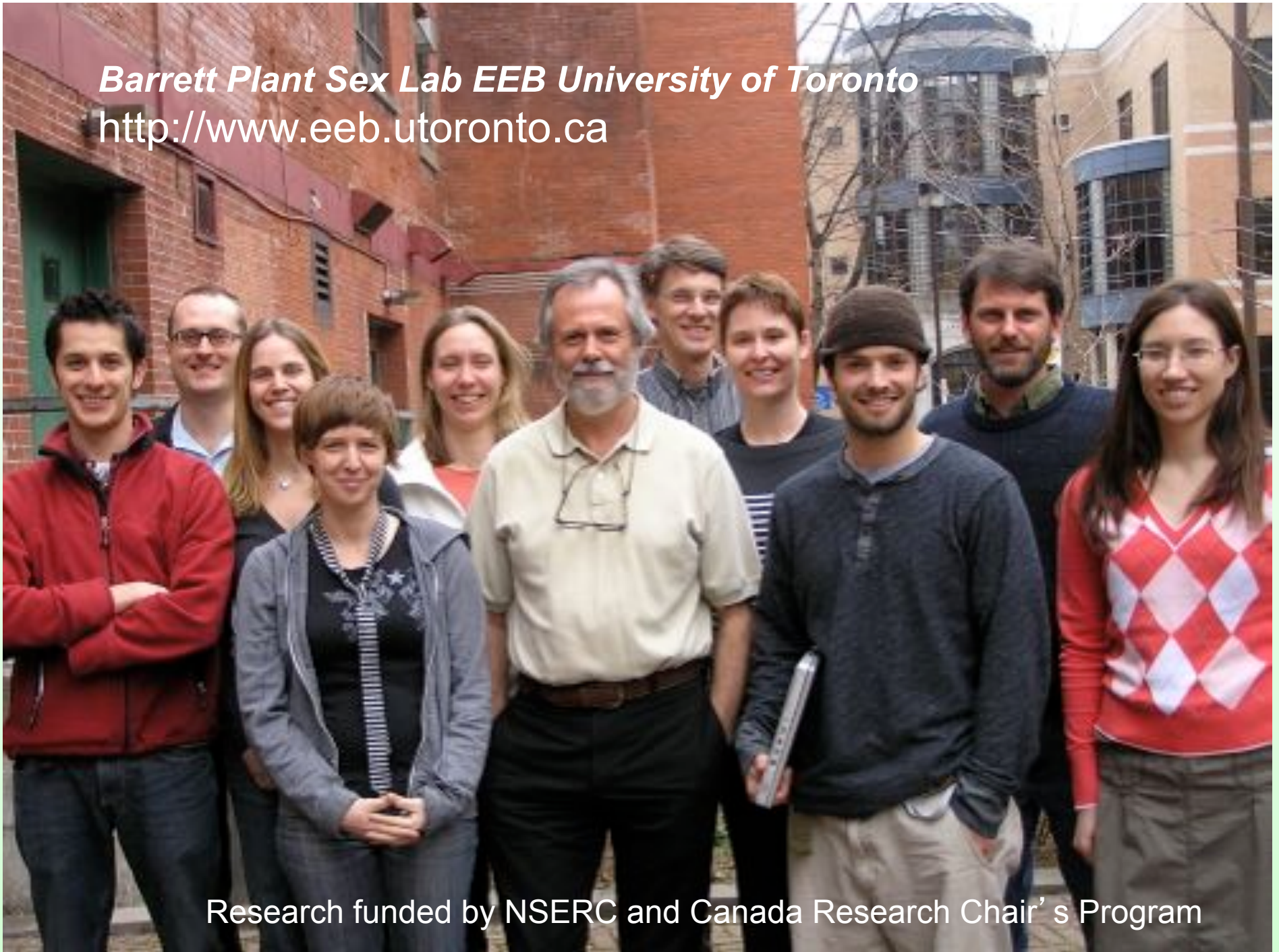
Floral diversification in Gingers



Photos courtesy of Qing-Jun Li

Barrett Plant Sex Lab EEB University of Toronto

<http://www.eeb.utoronto.ca>



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Major Evolutionary Transitions in Plant Reproductive Systems

Hermaphroditism
animal pollination
outbreeding

Decreased flower size

Spread of
sterility mutations

Loss of adaptations
for animal pollination

Selfing

Separate
sexes

Wind
Pollination

Projects from the Barrett lab on plant sex and mating

- Discovery of Darwin's missing sexual form of water hyacinth
- The evolution of males and females
- The evolution of a specialized bird perch



Water hyacinth - Eichhornia crassipes¹⁸

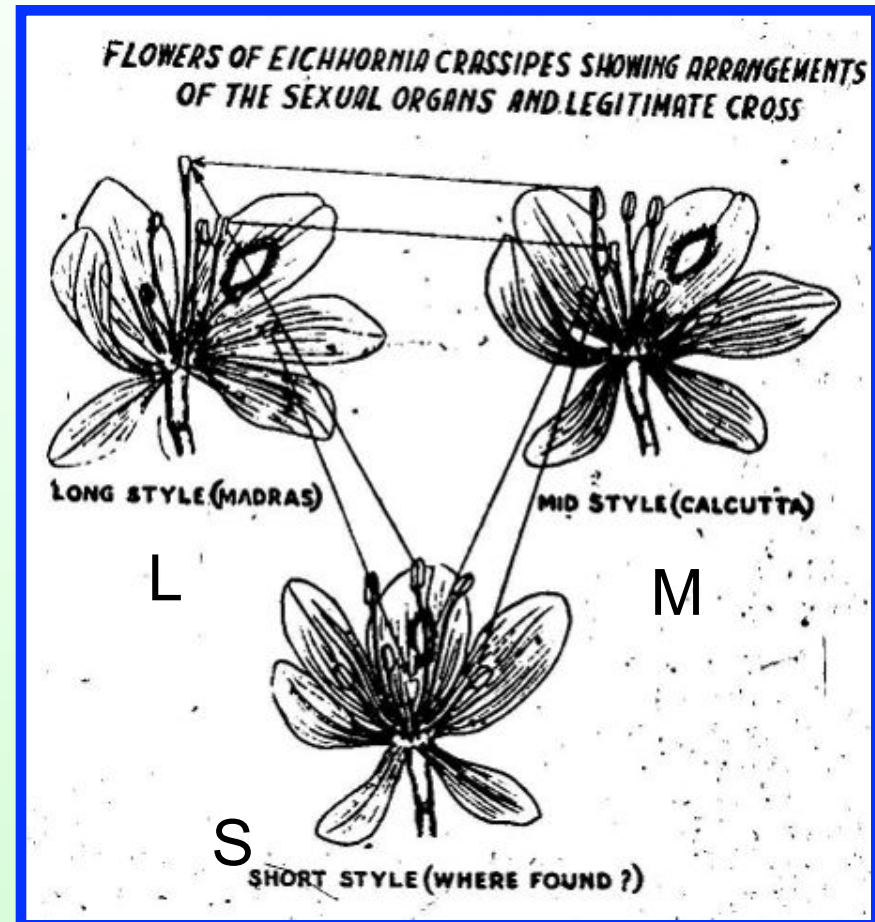
*Water hyacinth reproduces by
cloning and sex*



Mystery of Darwin's missing short-styled (S) form of water hyacinth



J. B. S. HALDANE



JBS Haldane (1960)
J. Bombay Nat. Hist. Soc.

Lower Amazon 1974

Found it!

Biotropica (1977)



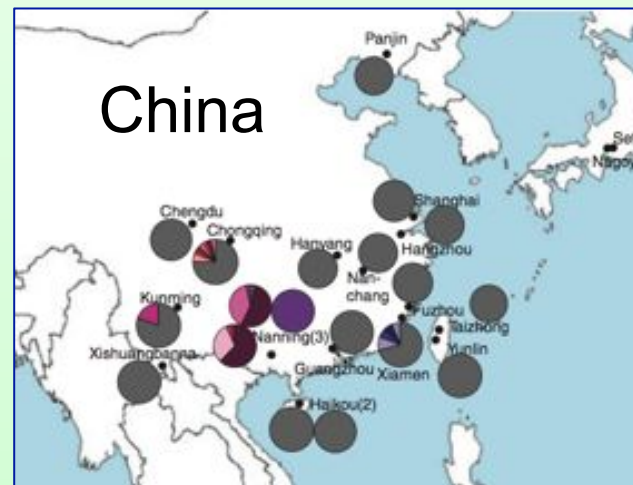
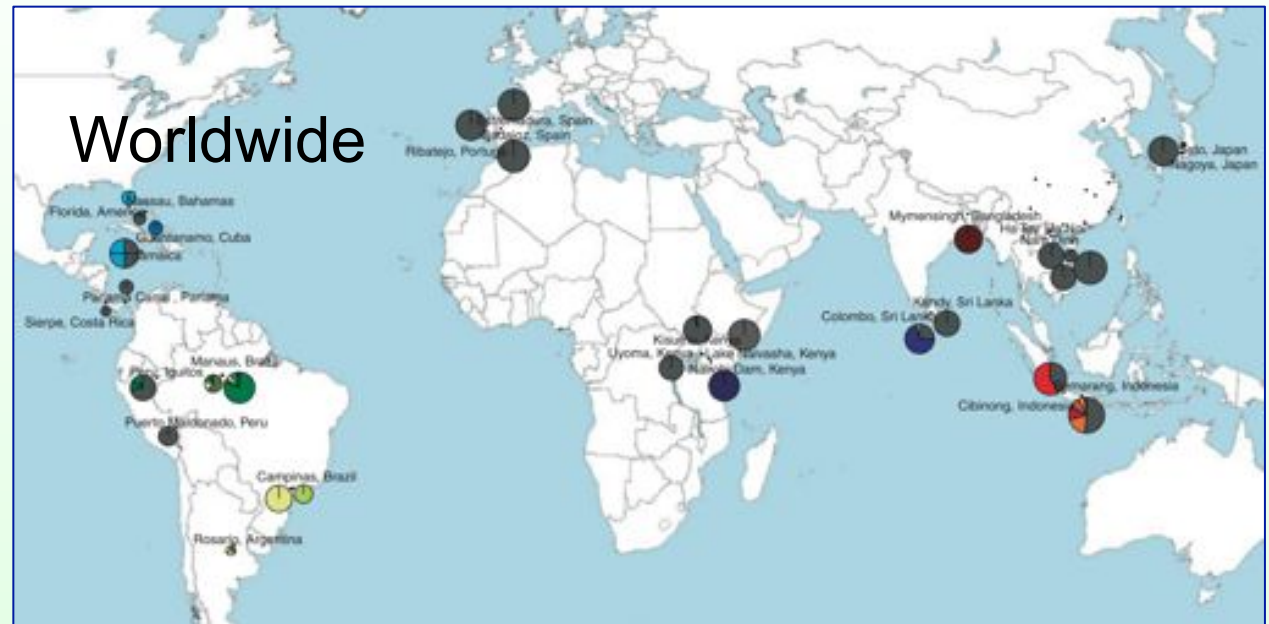
Recent survey of genetic diversity in water hyacinth



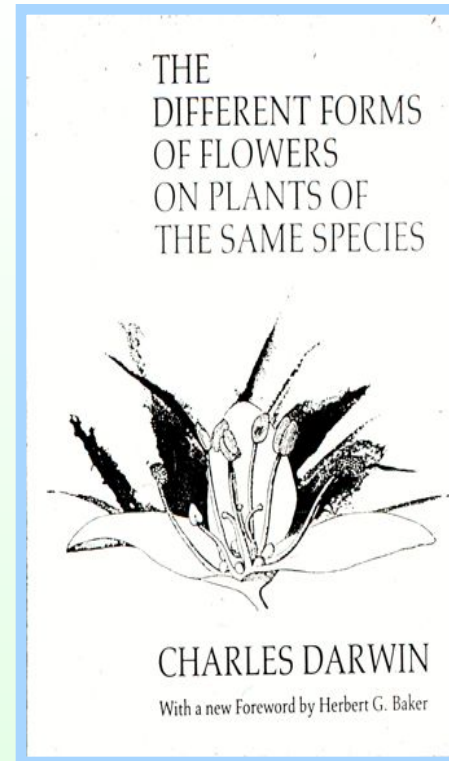
Da-Yong Zhang



Yuan-Ye Zhang



Molecular Ecology (2010)



“There is much difficulty in understanding why hermaphrodite plants should ever have been rendered dioecious”

Darwin 1877



Balanophora



Cannabis



Silene



Leucadendron

Multiple Origins of Dioecy



Schiedea



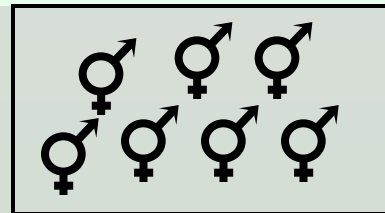
Thalictrum

Sagittaria latifolia

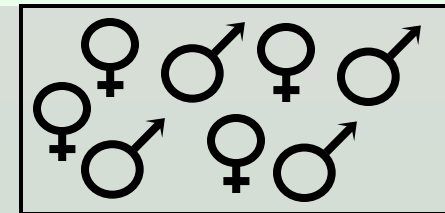
Three sexual phenotypes



Two primary sexual systems



Monoecy



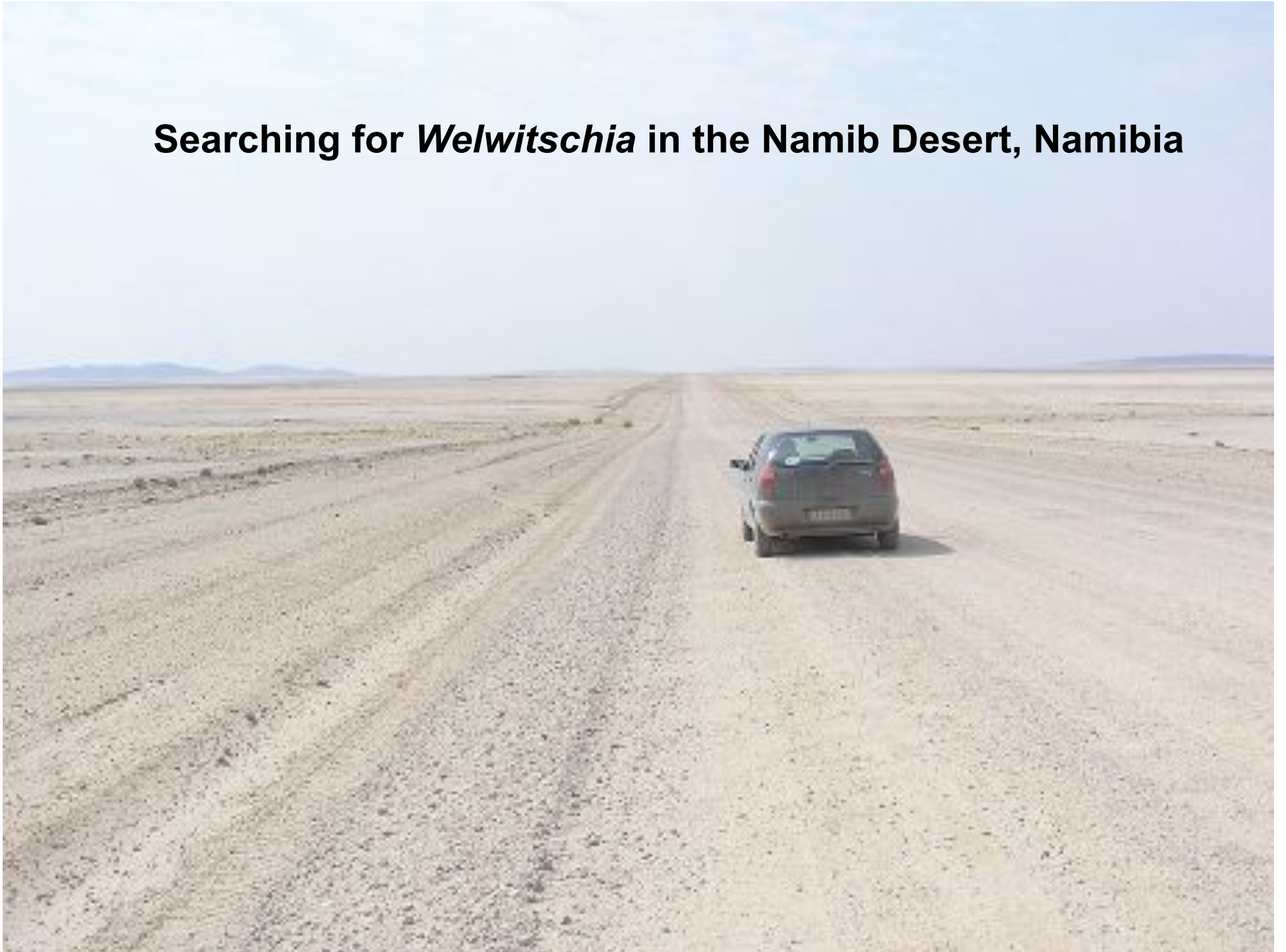
Dioecy

Ecological differentiation



Evolution (2002) 56: 31-41
Evolution (2003) 57: 1973-1988

Searching for *Welwitschia* in the Namib Desert, Namibia



Seen any yet?



***Welwitschia mirabilis* - Welwitschiaceae**



Protea cynaroides - Proteaceae





***Babiana ringens* (Rat's Tail)**
What pollinates this plant?

Bird pollination evolved independently in many lineages of angiosperms



Hummingbirds



Sunbirds



Honey-eaters

primary bird groups that serve as pollinators

Primary feeding strategies of flower-visiting birds

**New
World**



Hovering

**Old
World**



Perching

***Babiana team – Western Cape, South
Africa, September 2009***

Bruce
Anderson

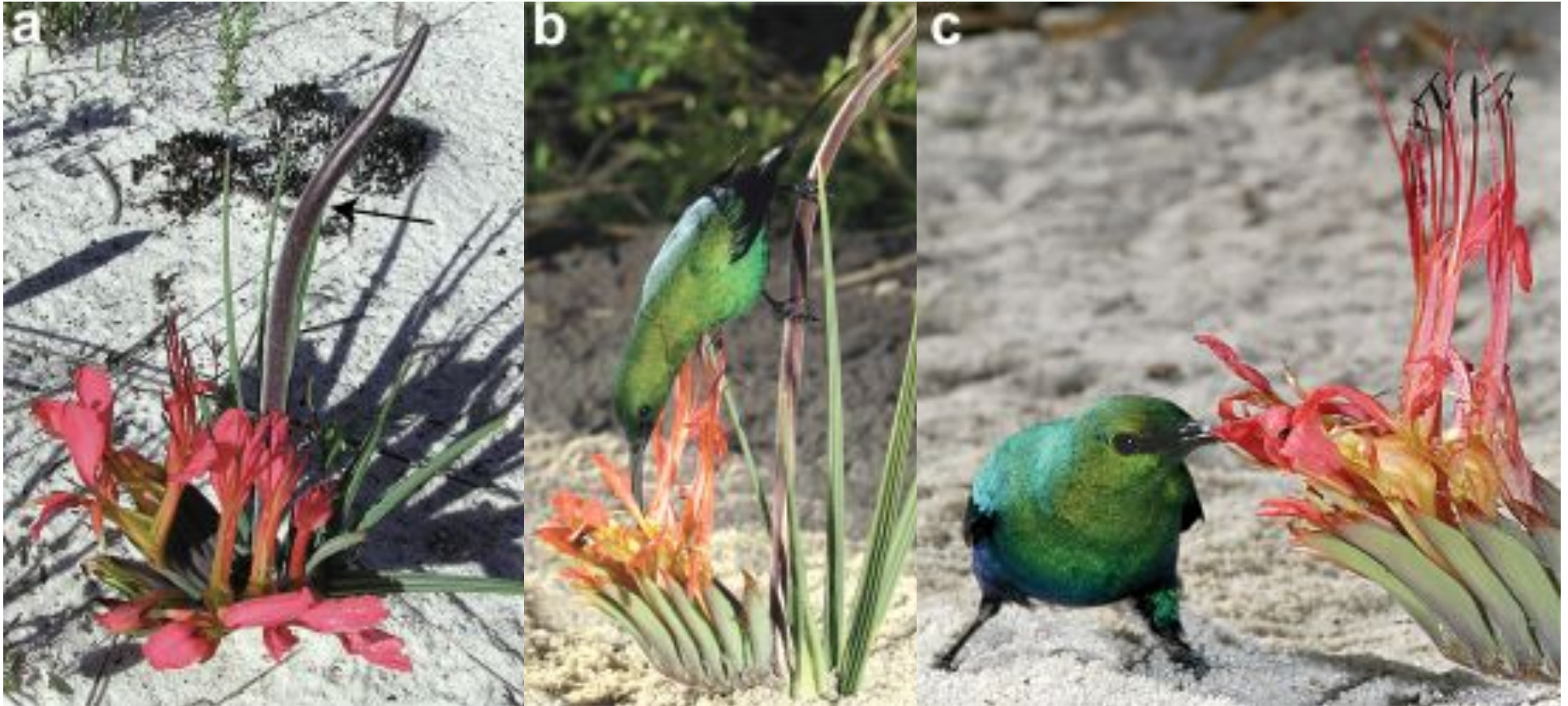
Caroli
de Waal



Specialized bird perch promotes reproductive success

Malachite

Malachite



Nature (2005)

Observation and manipulative studies indicate that malachite sunbirds are the only pollinators

Evolution of a bird perch?

Branched inflorescence



Babiana hirsuta

Ancestor ?



Babiana ringens

Unbranched inflorescence



Descendant ?

Future Puzzles in Plant Sexotica from Exotic Places

What is the function of these bizarre plant structures?

- **Long whiskers - *Tacca chantrieri* – Yunnan, China**
- **Long tubes - *Lapeirousia anceps* – South Africa**
- **Puffy pouches - *Calceolaria uniflora* – southern Patagonia**

Dr Chris Eckert of Queens University enthralled
by the strange flowers of *Tacca*



The case of “sapromyophily” in *Tacca chantrieri*



Amer J Bot 2005 92: 517-524



***Lapeirousia anceps* - Iridaceae has bimodal floral tubes**

Long-tongued fly pollinates *L. anceps*



Moegistorhynchus longirostris



Ornamental Calceolaria




Search for *Calceolaria uniflora* in Southern Patagonia



Fitz Roy Massif, El Chalten





**Pollination by Least
Seedsnipe?
(*Thinocorus rumicivorus*)**

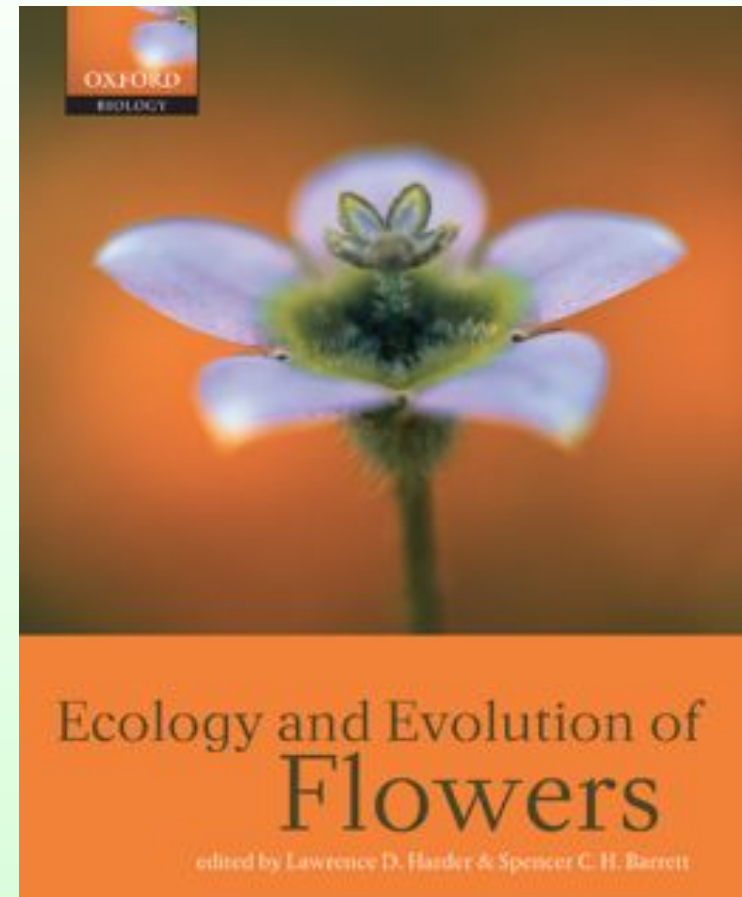
**Fleshy white
food body
eaten by birds**

Calceolaria uniflora

Today's General Messages

- **Understanding plant sex is important for both basic and applied science**
- **Plants display stunning floral diversity related to their complex sex lives**
- **Flowers are both beautiful and a lot of fun to study!**

Further Reading



<http://ukcatalogue.oup.com/product/9780198570868.do>