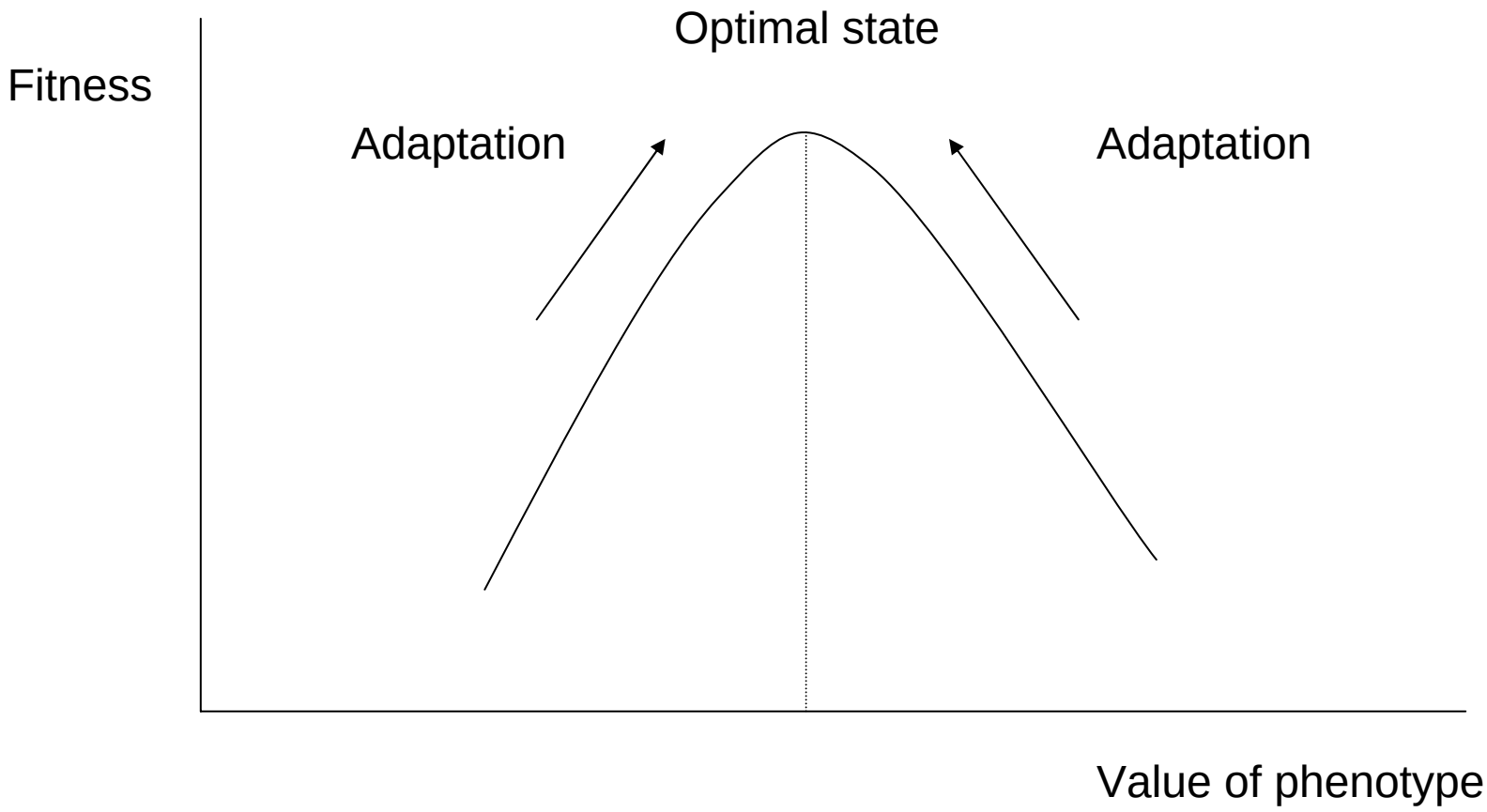
2009年10月27日

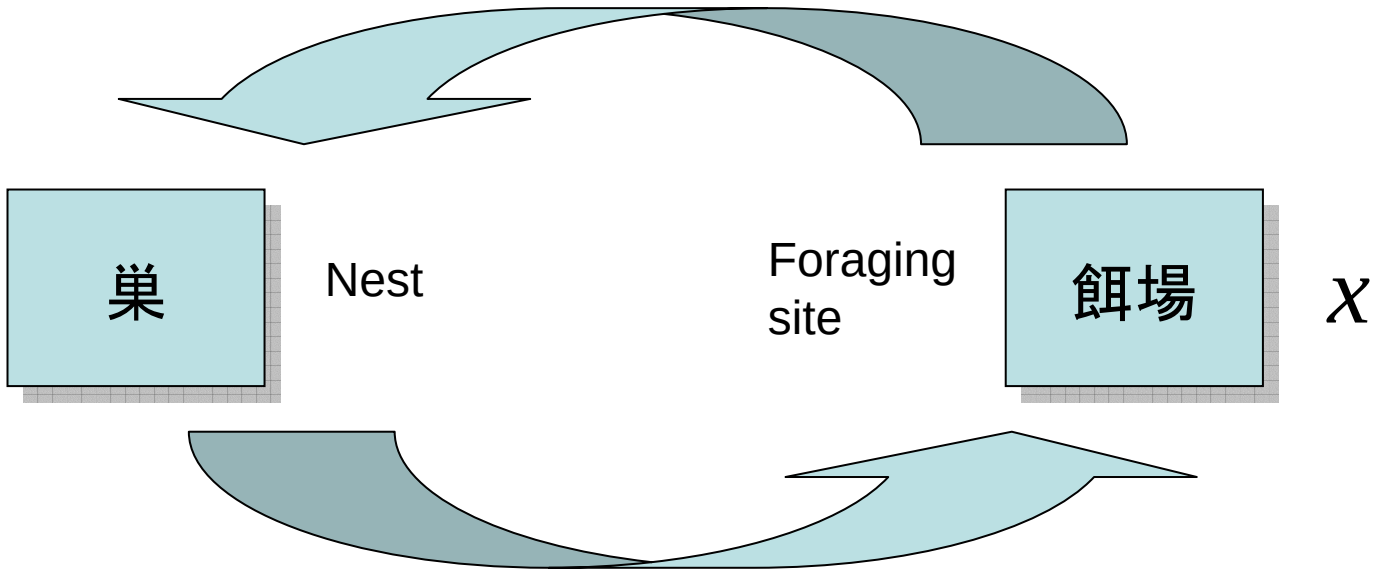
生態学Ⅰ　第3回

最適採餌戦略
optimal foraging strategy
性配分戦略
sex allocation strategy

Graphical representation of adaptation



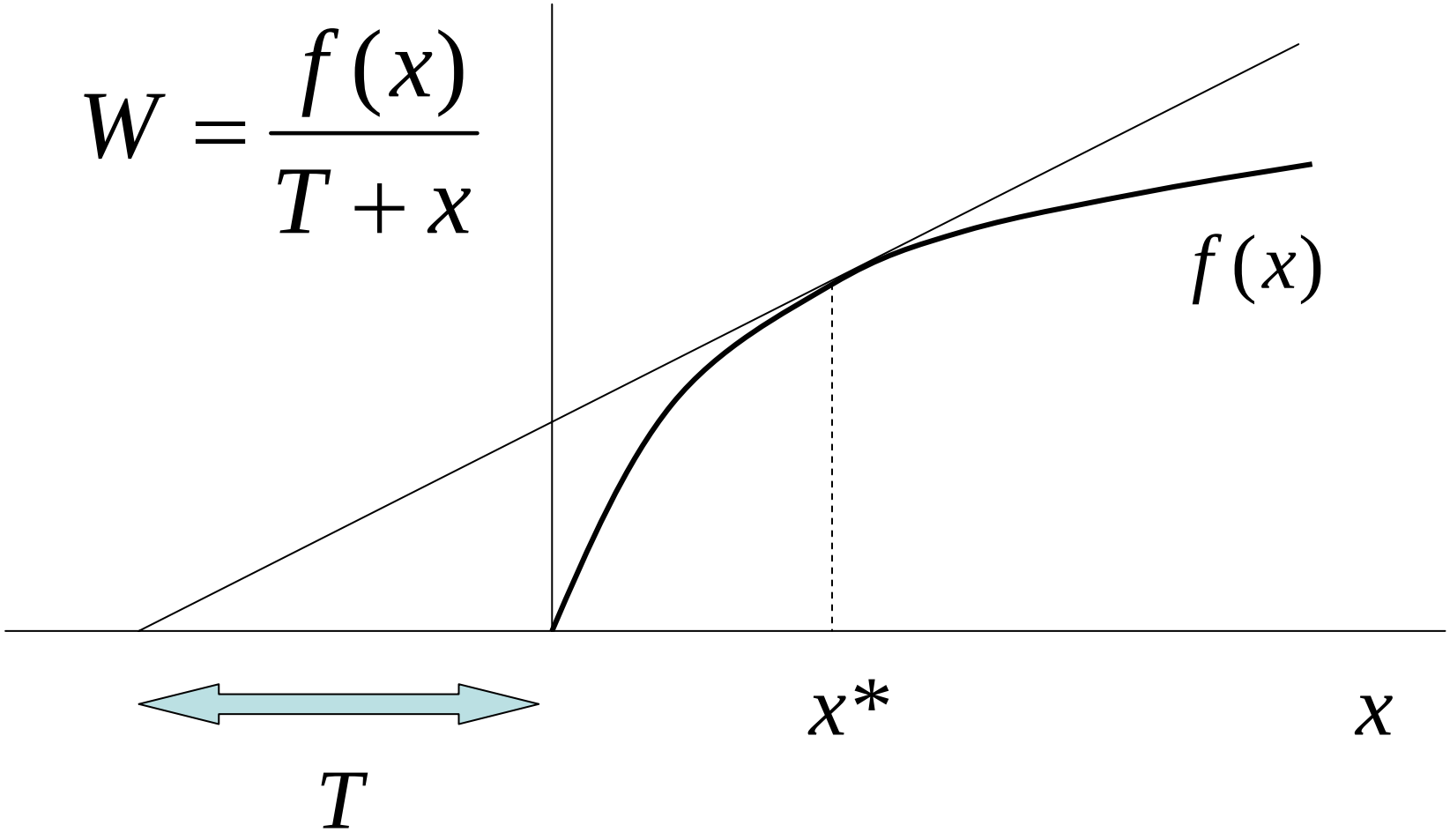
Optimal foraging strategy
最適採餌戦略



T

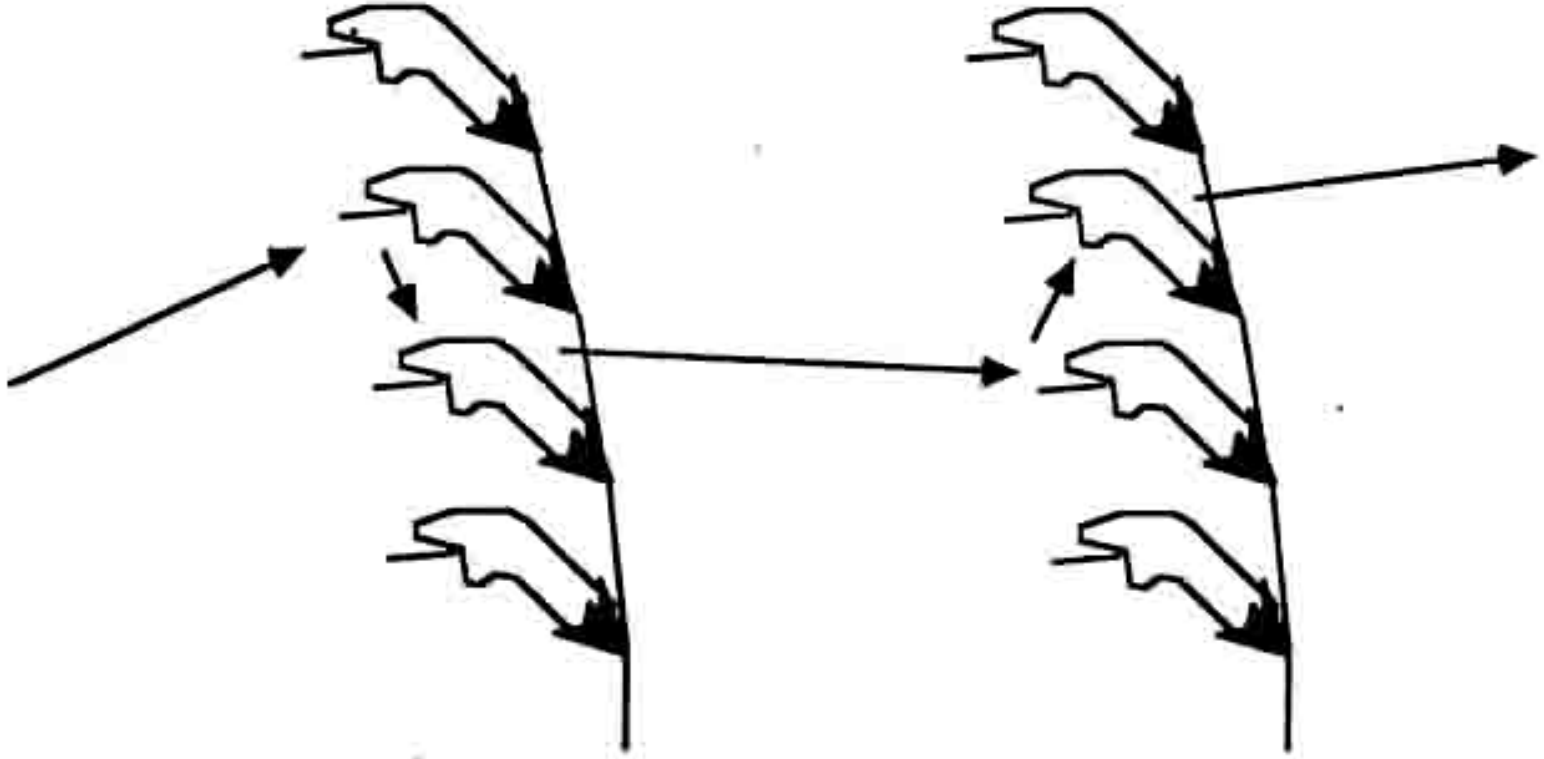
How long should an animal stay on a foraging site?

Optimal foraging strategy
最適採餌戦略



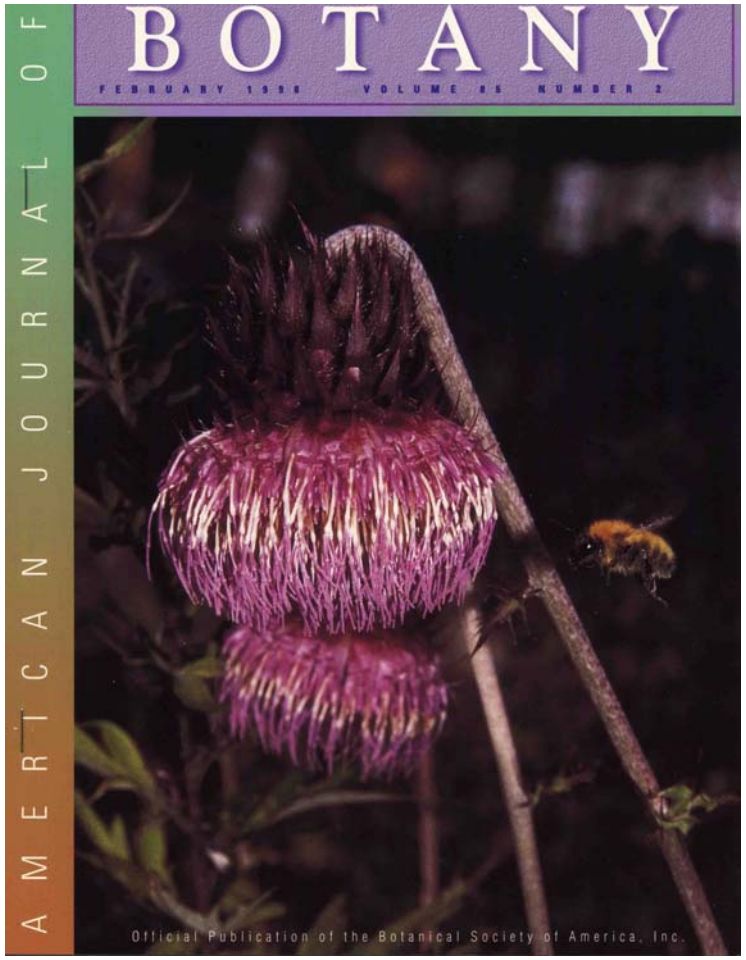
Curious (apparently non-adaptive) behaviour of pollinators

Visit a few flowers per plant and fly to another plant



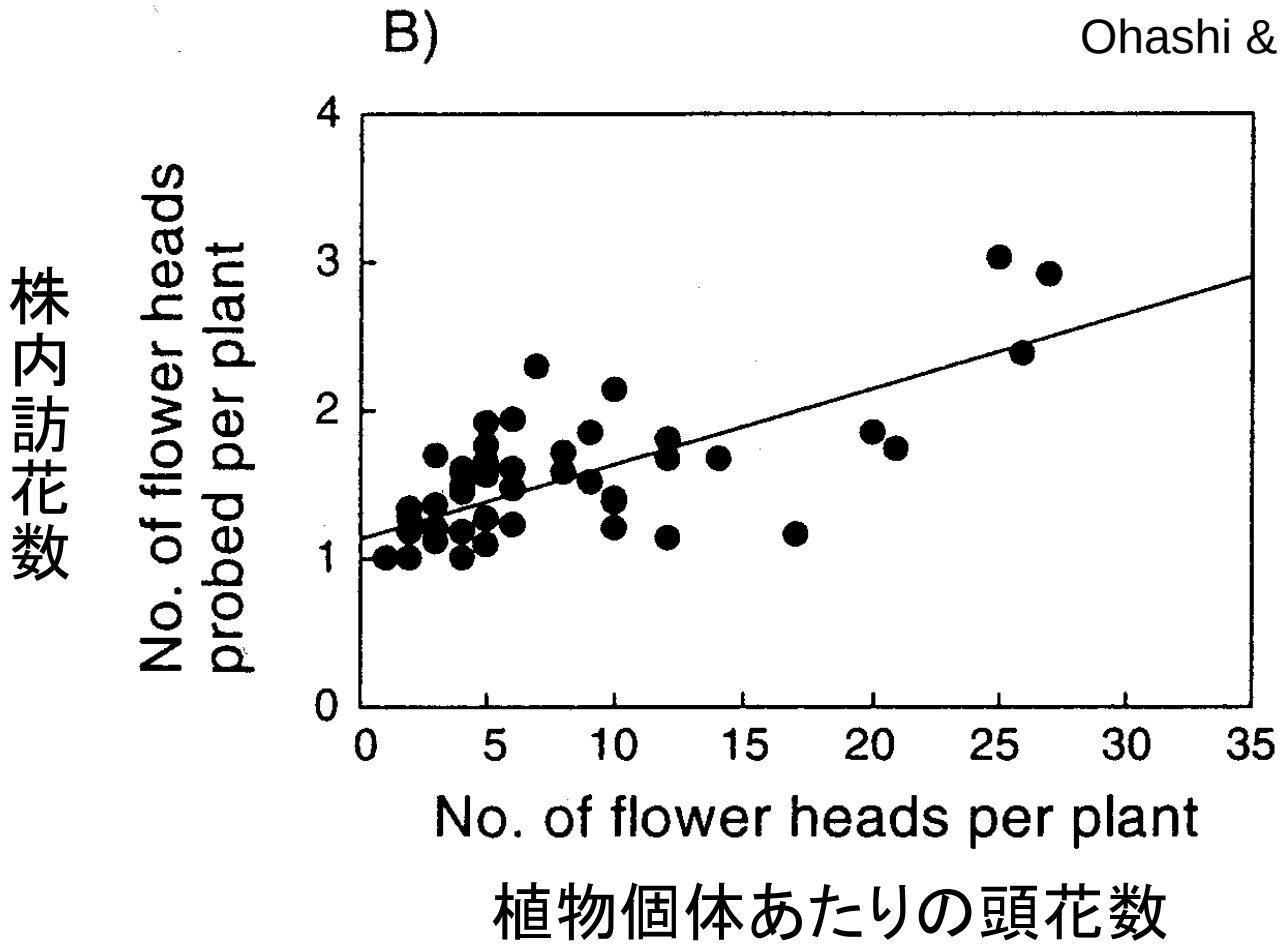
植物にとっては隣花受粉を少なくする有益な効果

Cirsium purpuratum and bumblebees
フジアザミとマルハナバチ

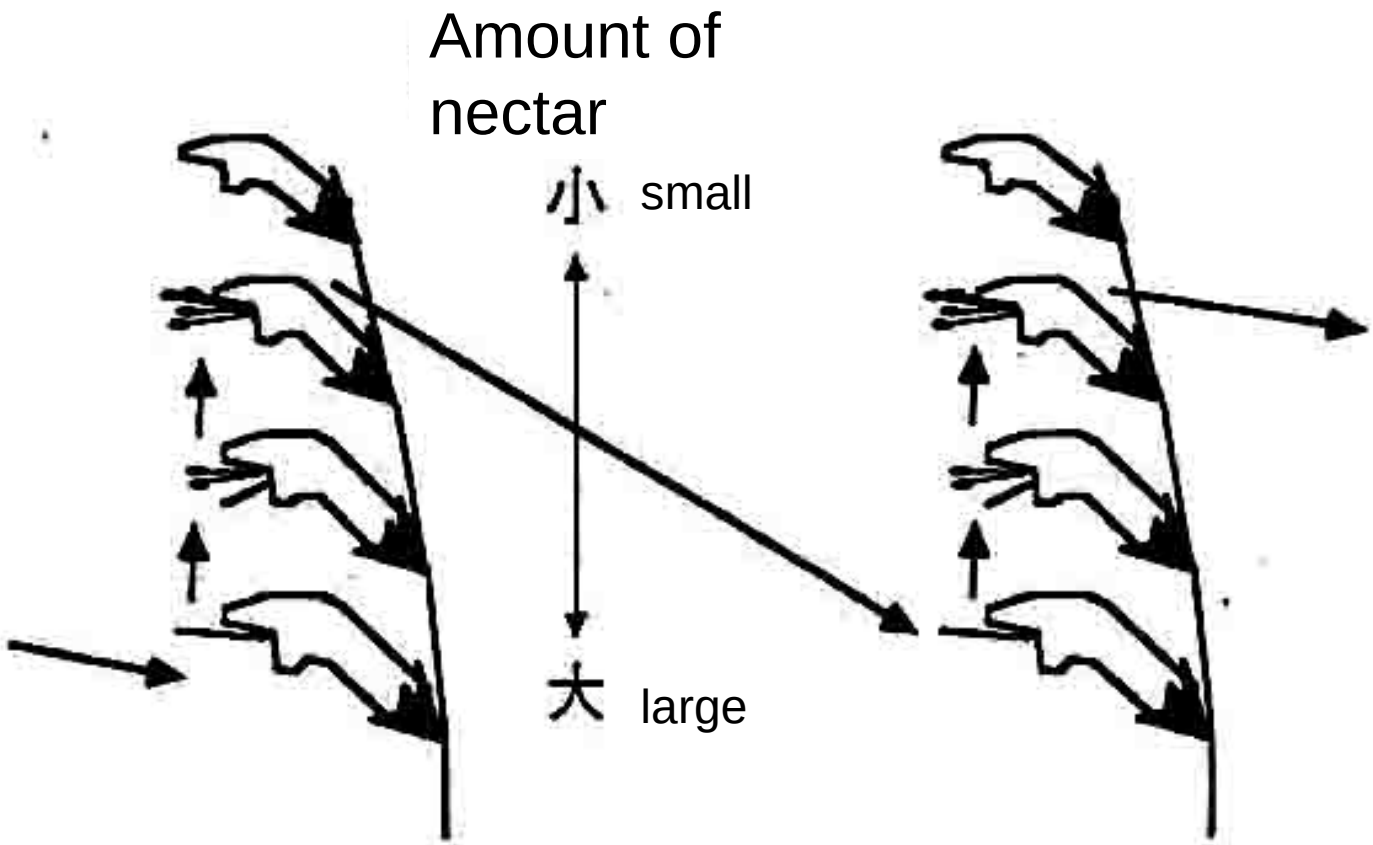


Ohashi & Yahara(1998)
Amer J Bot 85:219-224

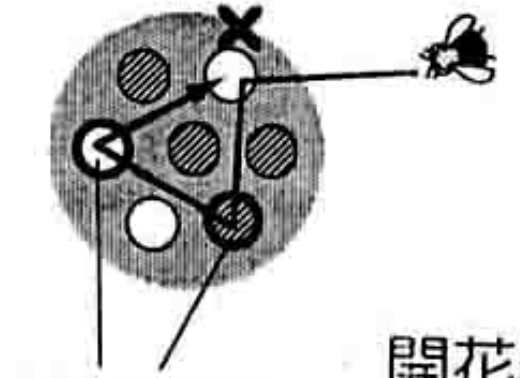
フジアザミの花数とトラマルハナバチの株内訪花数の関係



Floral strategy to manipulate pollinator behaviour;
in the case that flower positions are easy to remember



Ohashi & Yahara model



$G_{t+1} = \dfrac{Fp - n}{F - m}$

開花数

すでに出会った「アタリ」の花数

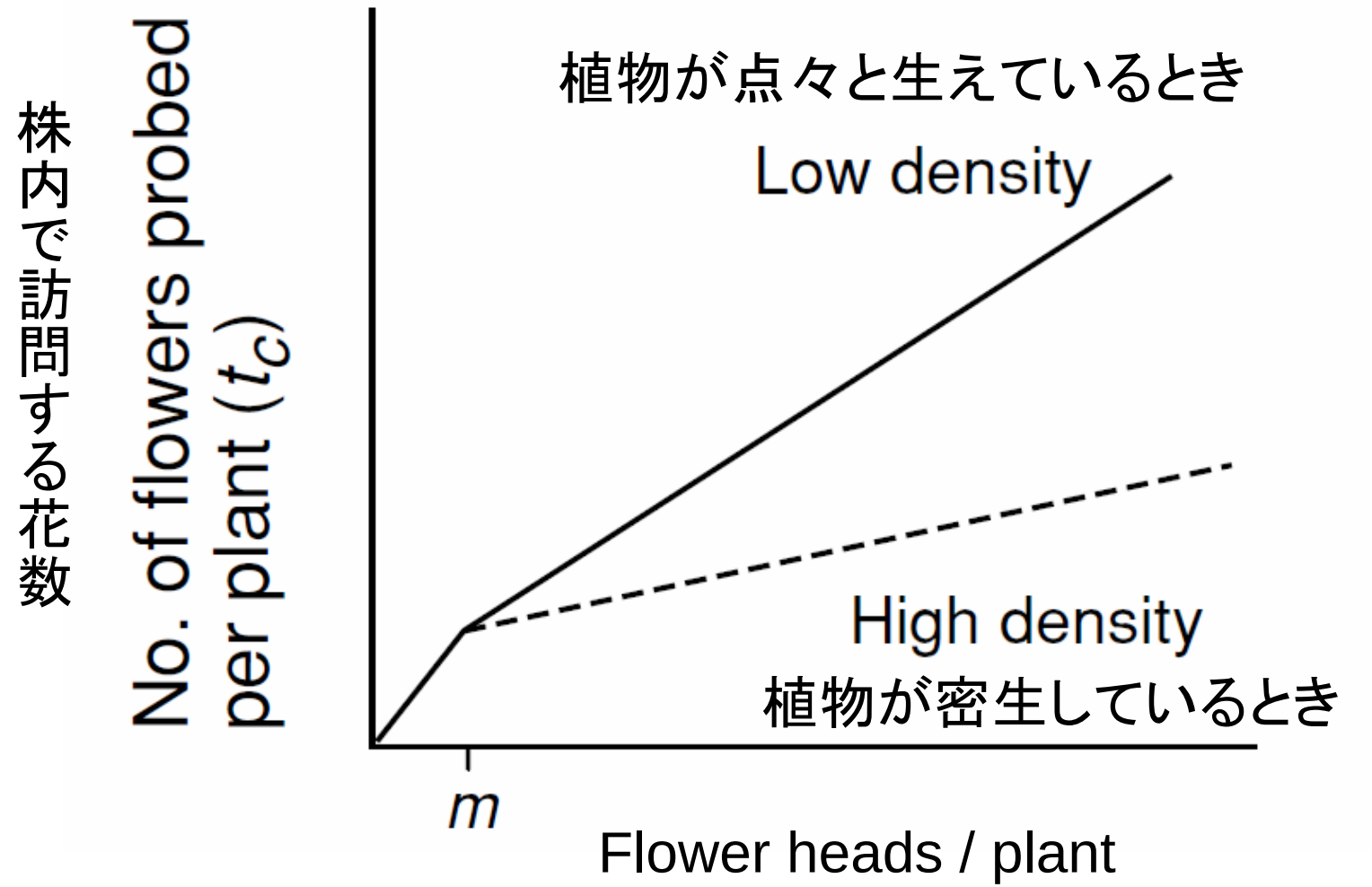
回避する m個の花

mは短期記憶の上限値

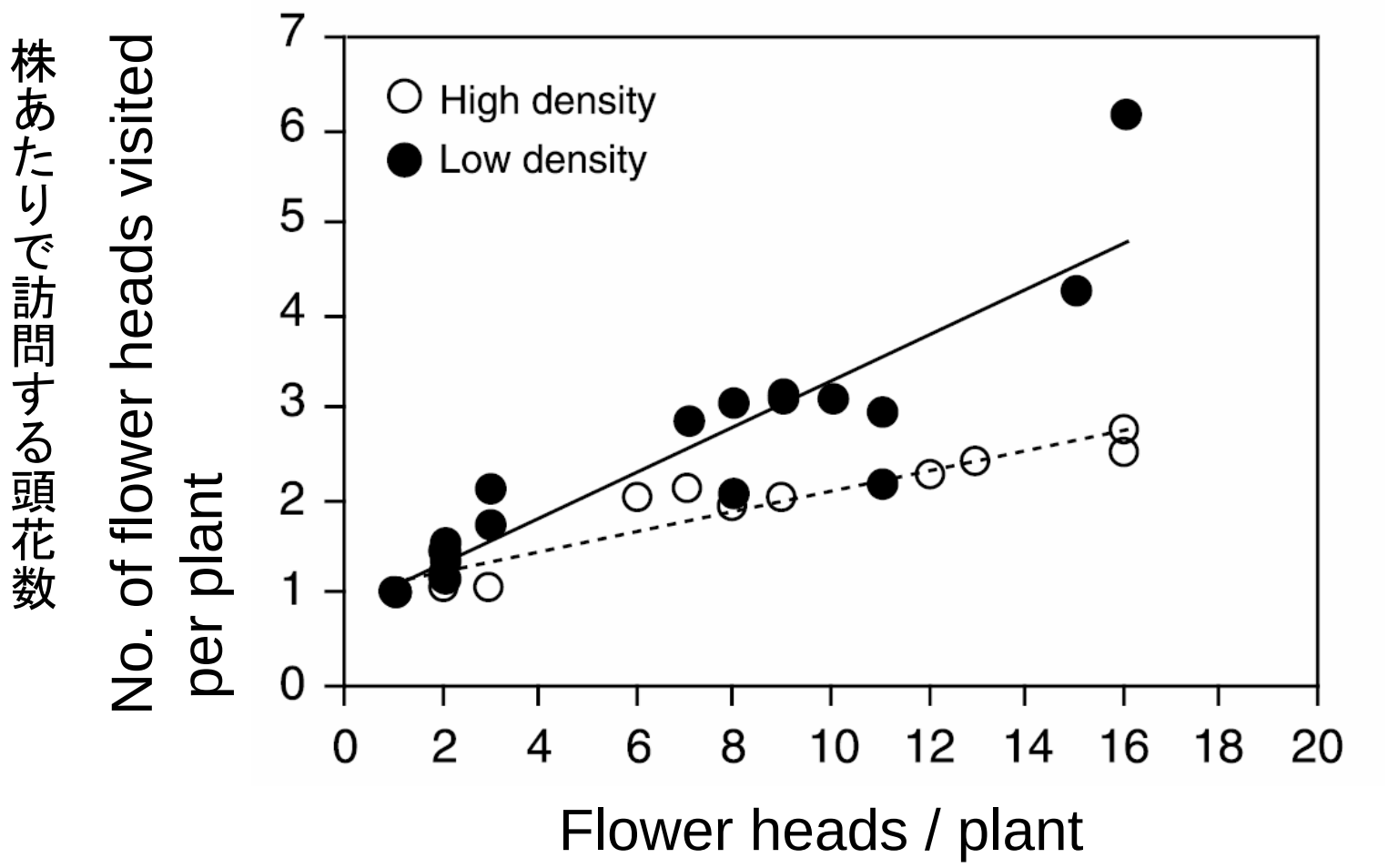
境界は $\dfrac{Fp - n}{F - m} = kp$

立ち去り条件は$G_{t+1}<kp$

Predictions of Ohashi & Yahara model



Observed bumblebee behaviors



Ohashi & Yahara (2002) Func Ecol 16: 492-503

Stamen-removal experiment in Salvia nipponica

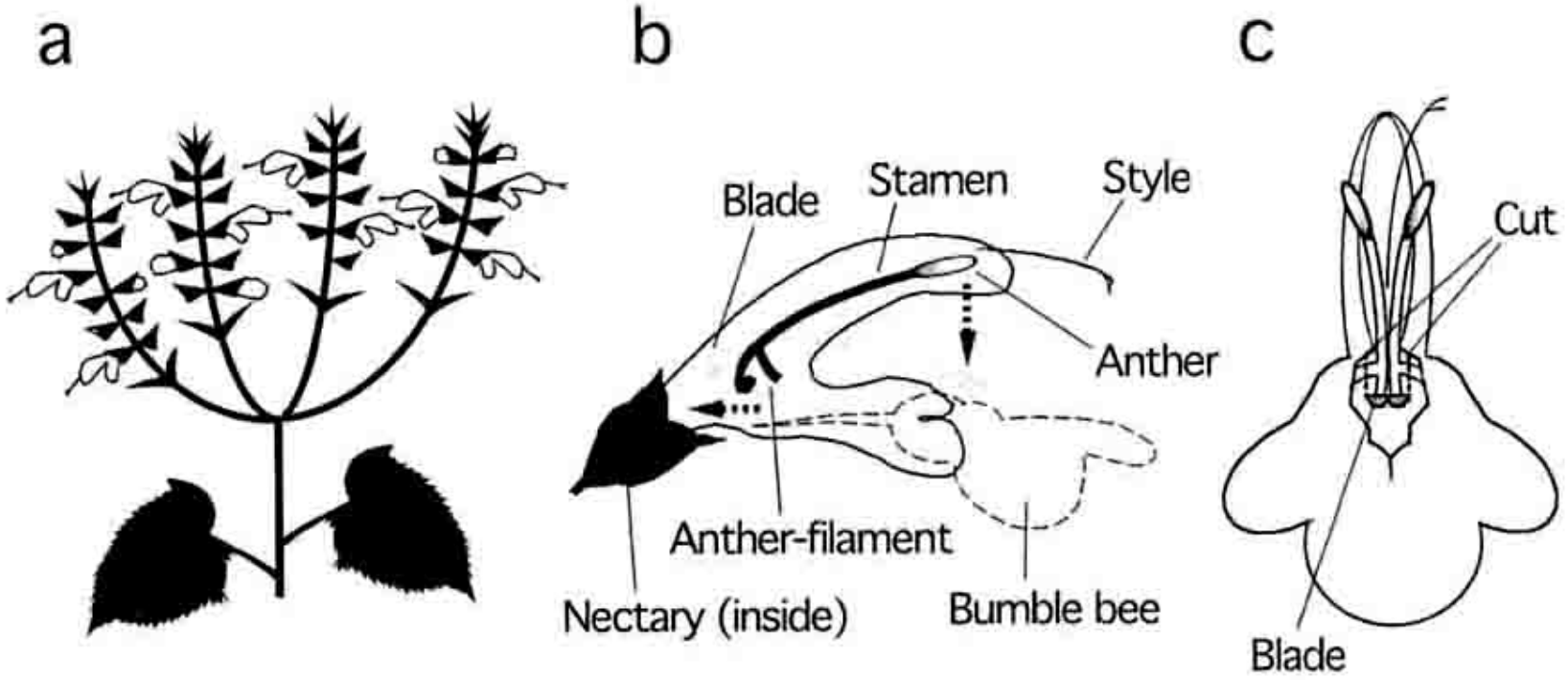


FIG. 1. Views of *Salvia nipponica*. (a) Flowering plant with four racemes, each of which bears two or three open flowers and no or two buds. (b) Half-section of a flower, showing the broadened lower end and the fertile anther cell on the upper end of one of the two fully developed anthers. Arrows and gray-colored stamen indicate the movement of the see-saw mechanism when a bee (dashed line) crawls into the flower. Immediately after the bee leaves the flower, the elastic stamen swings up into upper lips (see text). (c) Front view of a flower. The broken lines are the location of cutting for stamen-removal treatment.

Ohashi (2002)
Evolution
56: 2414-2423

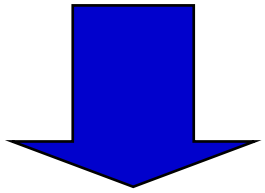
Cost of movement（k）

Handling time

Time of within-plant movement

$$\frac{\text{花あたり処理時間} + \text{株内移動時間}}{\text{花あたり処理時間} + \text{株間移動時間}}$$

Time of between-plant movement

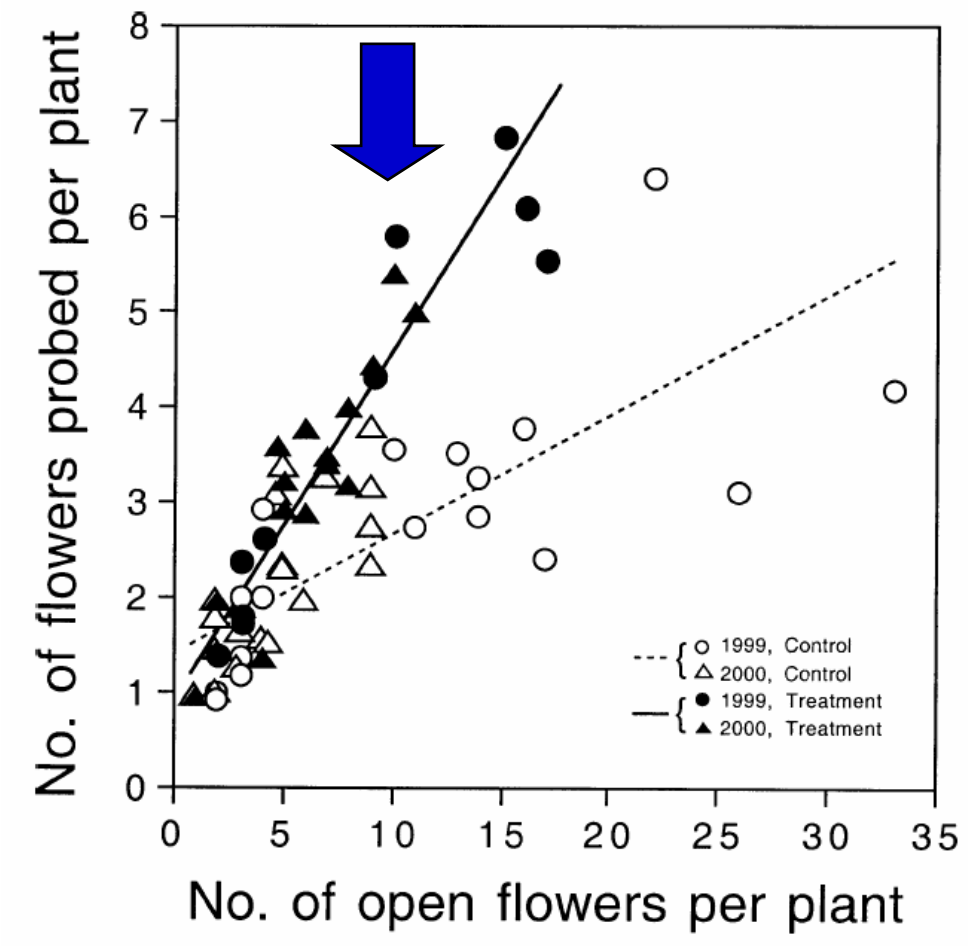


The larger the handling time is,
the sooner the bee leaves a plant.

Bumblebee foraging on flowers of *Salvia*

Flowers in which stamens were removed

株あたりの訪問花数



株あたりの花数

無処理の花

Control

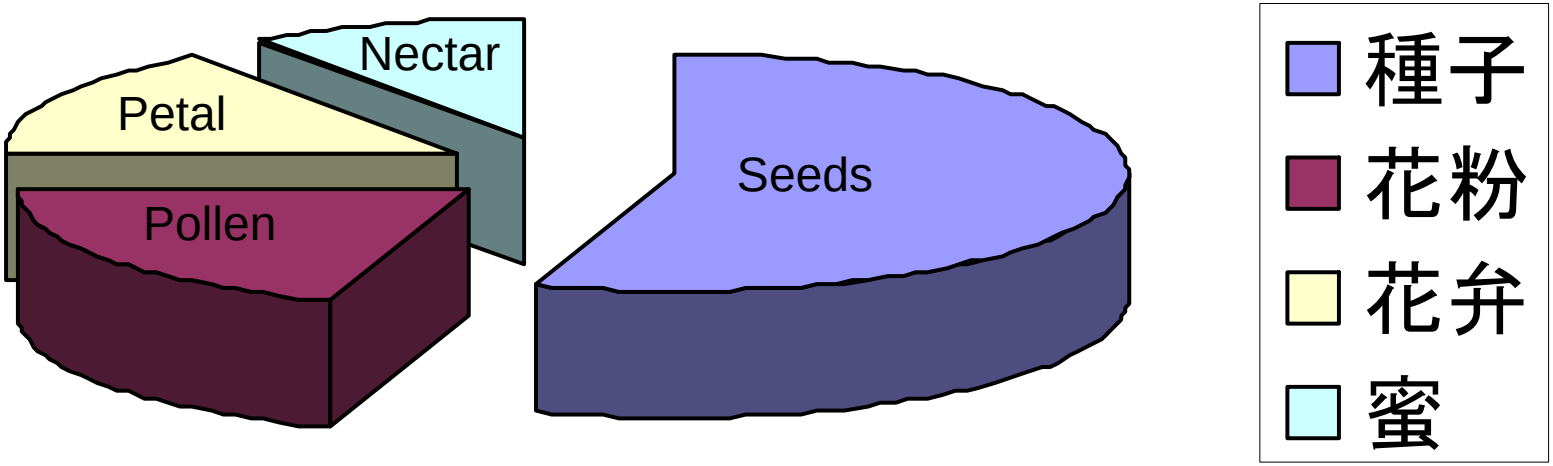
Ohashi (2002)
Evolution
56: 2414-2423

Key points (1)

- Prediction of optimal models is helpful to understand animal behaviour
  - Behaviors of many animals are consequences of adaptive evolution
- Pollinator behaviors are changed by floral traits
  - Plants can manipulate pollinator behaviors.
  - Pollinator behavior is a compromise between plant and pollinator adaptations.

Resource allocation and trade-off

Larger allocation to seeds should result in decreased allocation to other organs.

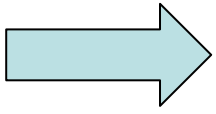


種子を増やせば、花粉・花弁・蜜への投資量が減ってしまう・・・・「トレード・オフ」（拮抗関係）

Sex allocation model

Fitness of a mutant $$W = \frac{1}{2} y + \frac{1}{2} x \frac{y^*}{x^*}$$

Fitness of a resident $$W = \frac{1}{2} y^* + \frac{1}{2} x^* \frac{y^*}{x^*}$$



Equal to the number of daughter, *y*

Sex allocation model

Fitness of a mutant $$W = \frac{1}{2} y + \frac{1}{2} x \frac{y^*}{x^*}$$

Resource allocation $$R = ax + by$$

Evolutionarily stable state（ESS） 進化的に安定な戦略

$$\left.\frac{\partial W}{\partial x}\right|_{x=x^*} = \frac{1}{2}\left(\frac{\partial y}{\partial x} + \frac{y^*}{x^*}\right) = \frac{1}{2}\left(-\frac{a}{b} + \frac{y^*}{x^*}\right) = 0$$

Female-biased sex ratio

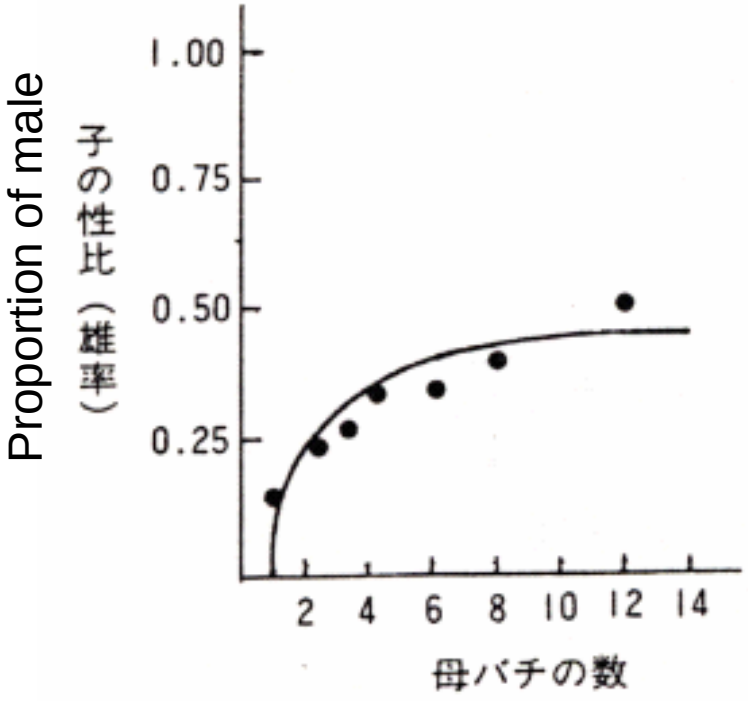
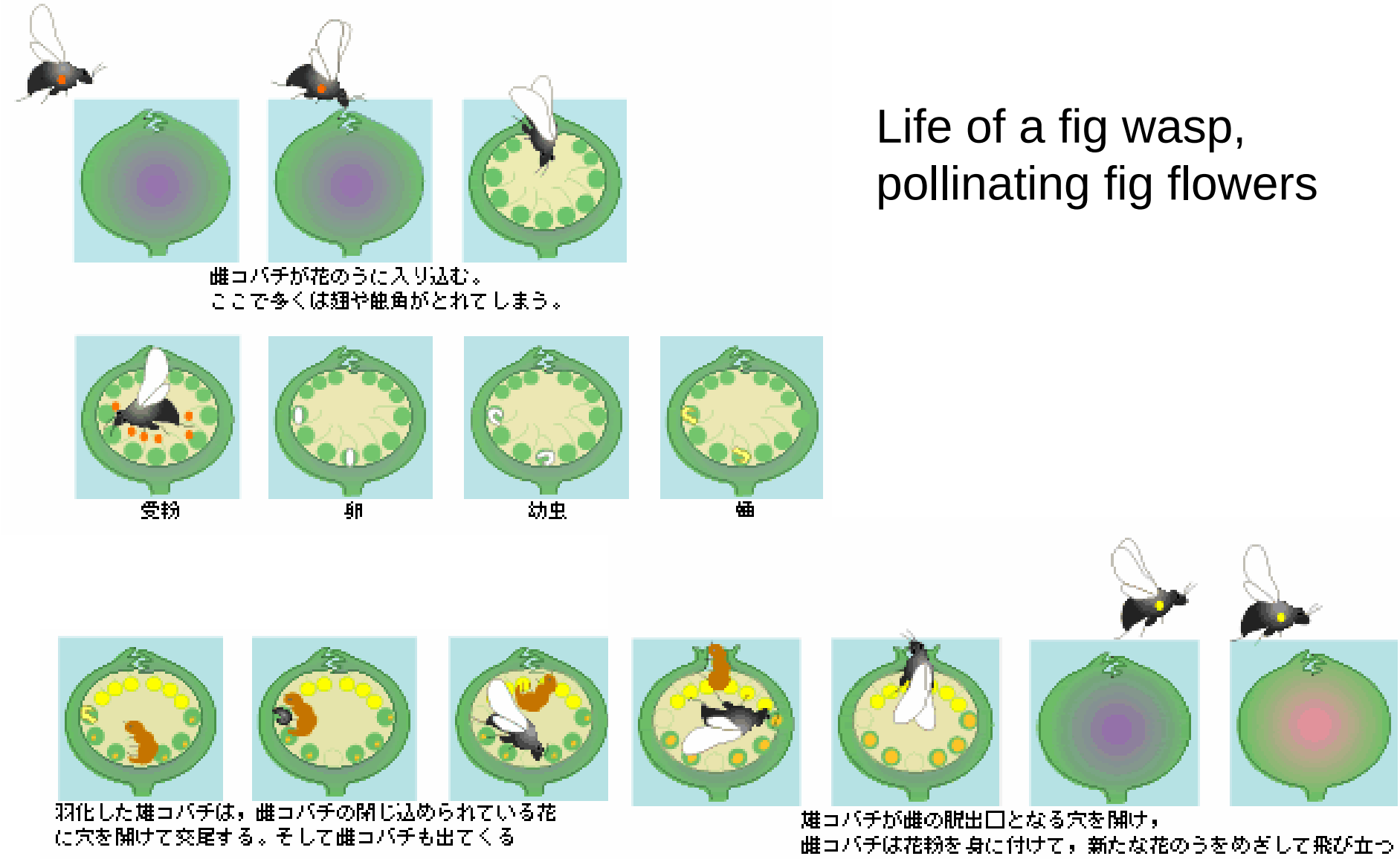


図 7-7　捕食寄生バチ *Nasonia vitripennis* の室内実験の結果．寄主の卵塊に卵を産ませたとき，雌バチの数が多いほど子の性比（子の総数に対する雄の子の数の比）は高くなり，0.5 に近づく（Werren, 1983 より）．

Fig and fig wasp

Life of a fig wasp, pollinating fig flowers



http://www.brh.co.jp/seimeishi/1993-2002/32/ss_2.html

局所的配偶競争（LMC)

Local Mate Competition

In case that the number of foundress *n* is small, the sex ratio of a mutant significantly changes the reproductive success of its offspring. Then,

$$W = \frac{1}{2} y + \frac{1}{2} x \frac{y + (n-1) y^*}{x + (n-1) x^*}$$

$$x^* = \frac{1}{2} - \frac{1}{2n}$$

Key points (2)

- トレードオフ trade-off
  - Increase of allocation to one function should decrease allocation to another function
  - Basic assumption of optimization model
- 性配分戦略 sex allocation strategy
  - Predicts 1:1 sex ratio under ordinary conditions
  - Female-biased sex ratio under LMC
  - An example of ESS