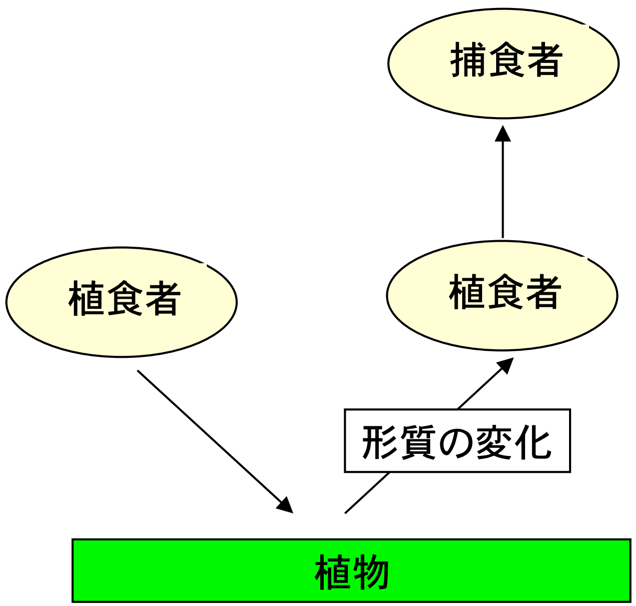
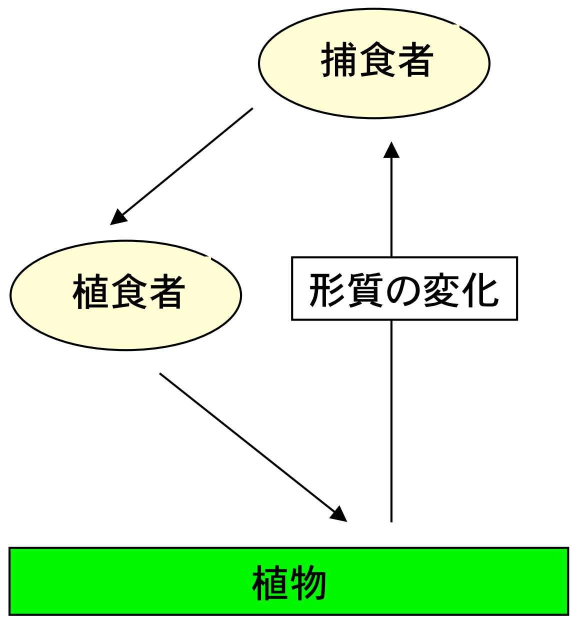
第6回
植物が生み出す新たな相互作用（2）

- 植物ー植食者ー捕食者の3栄養段階間の相互作用
- エコシステム･エンジニアが創る相互作用
- 相互作用から生物群集へ

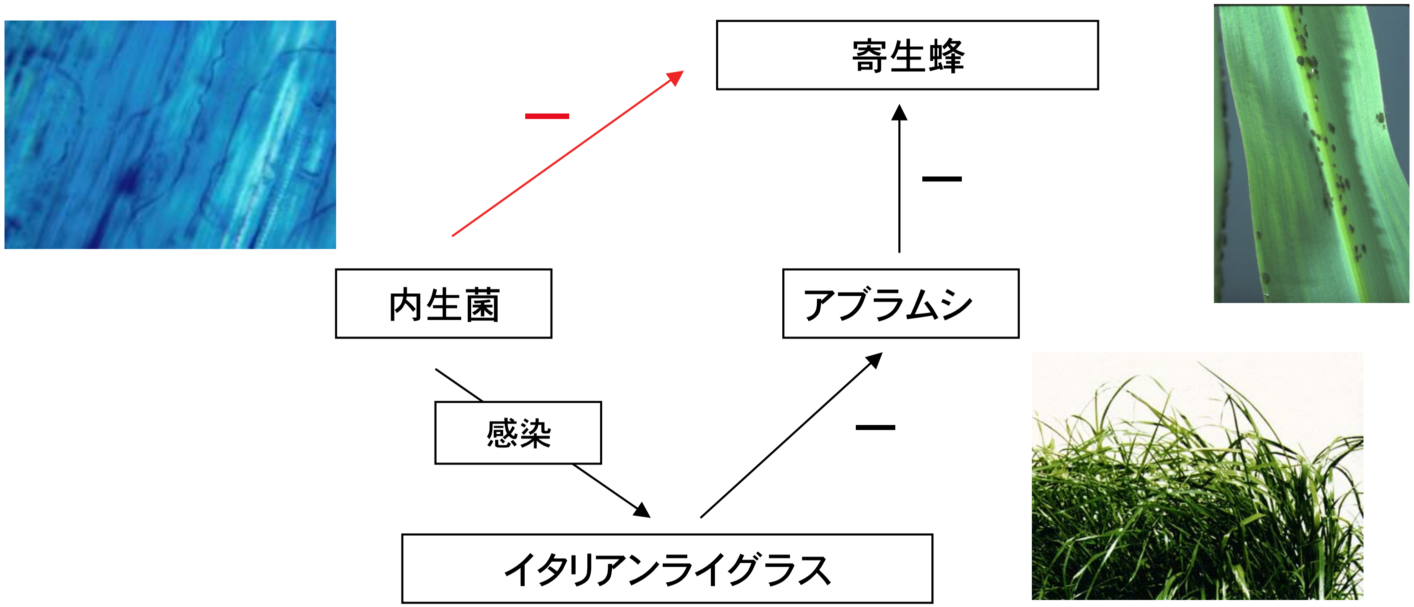
植物ー植食者ー捕食者の相互作用

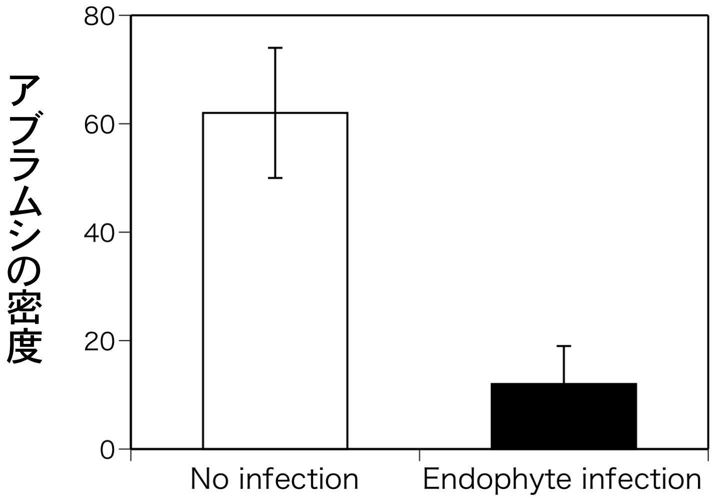
- 植物の形質の変化が、植食者を通して、捕食者に影響する
- 植物の形質の変化が、捕食者を通して、植食者に影響する

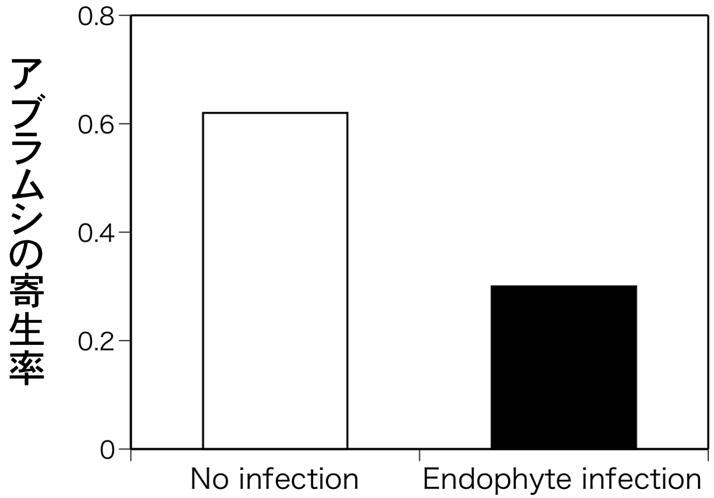




3栄養段階間の相互作用(1)

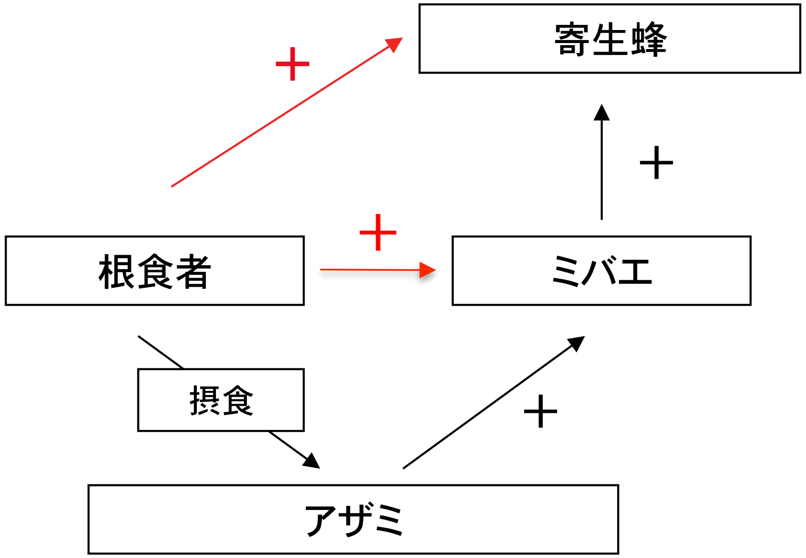


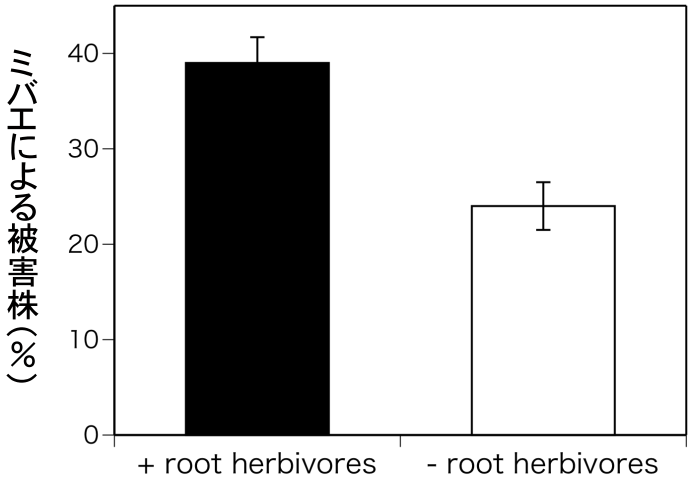


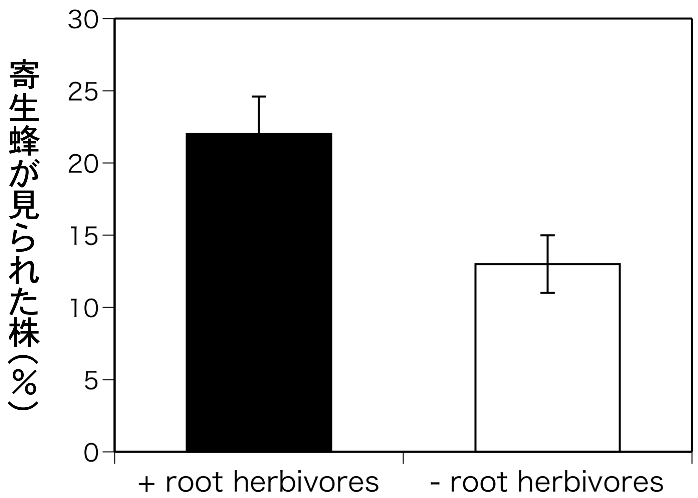


Omacini et al. (2001)

3栄養段階間の相互作用(2)

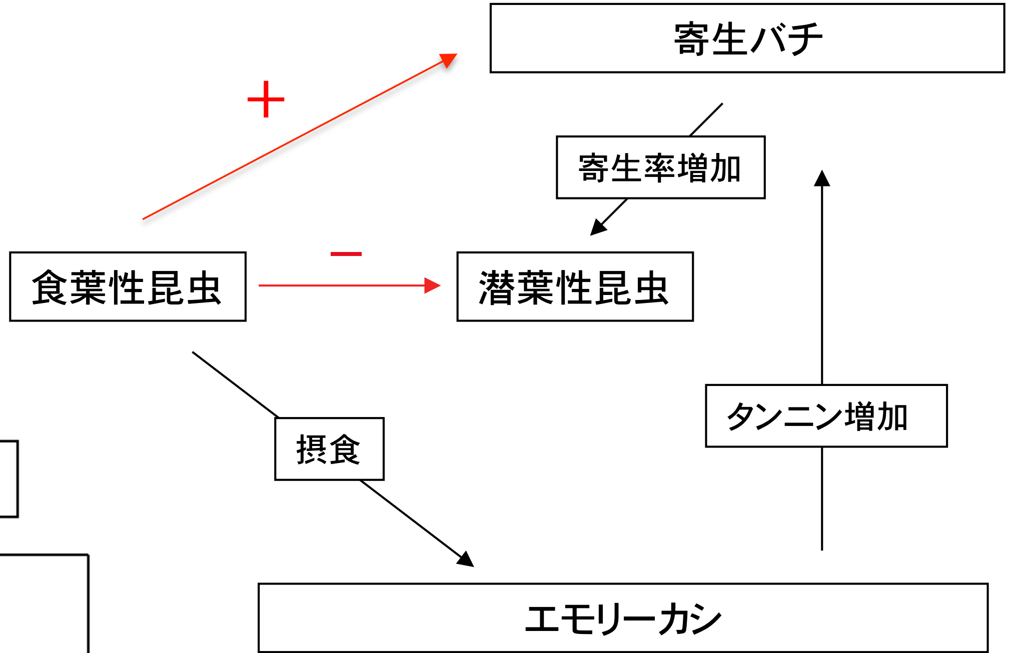


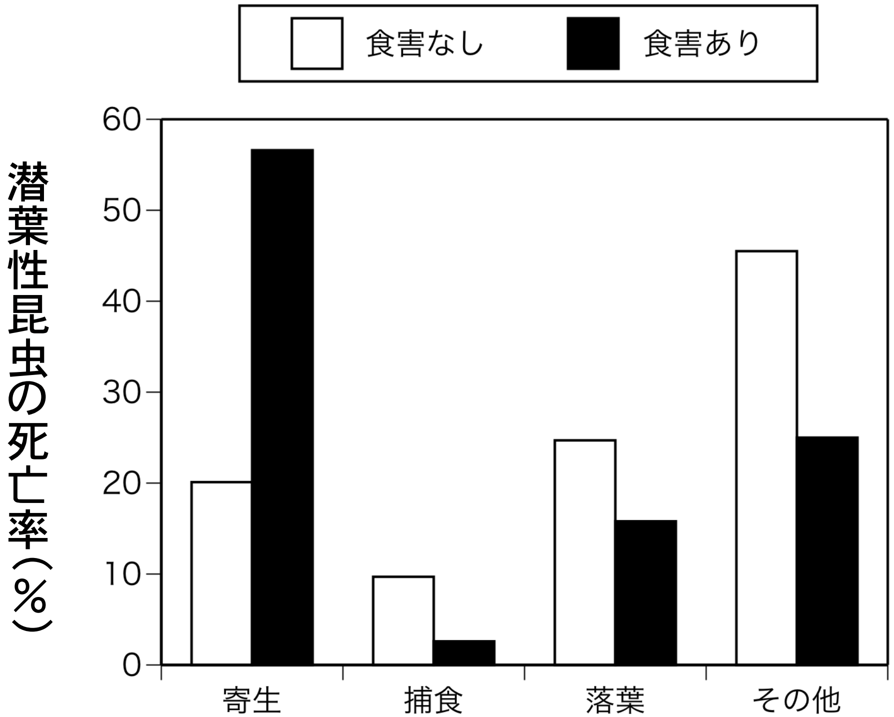




Masters et al. (2001)

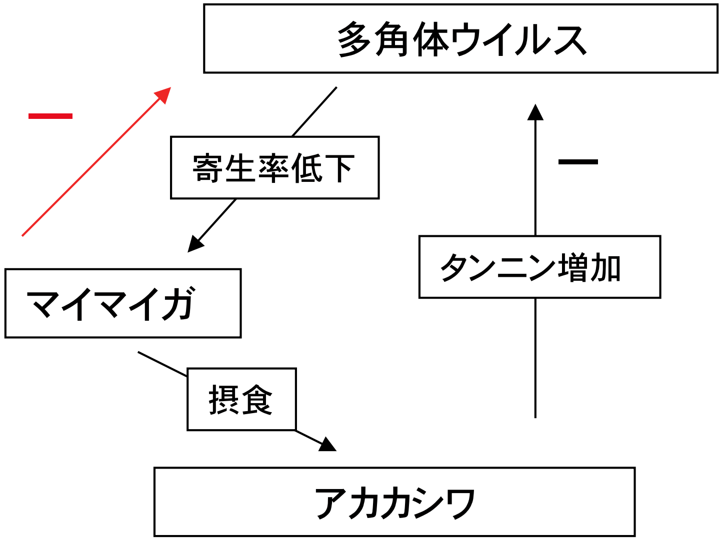
3栄養段階間の相互作用(3)

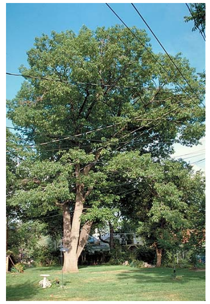


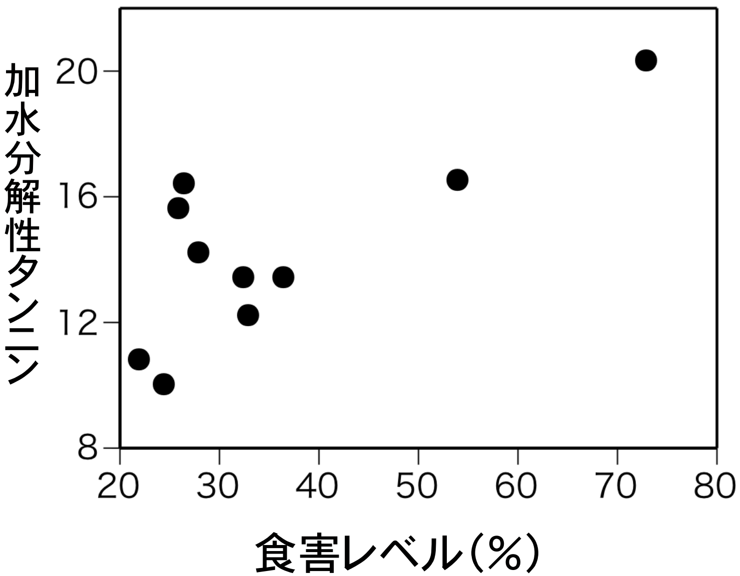


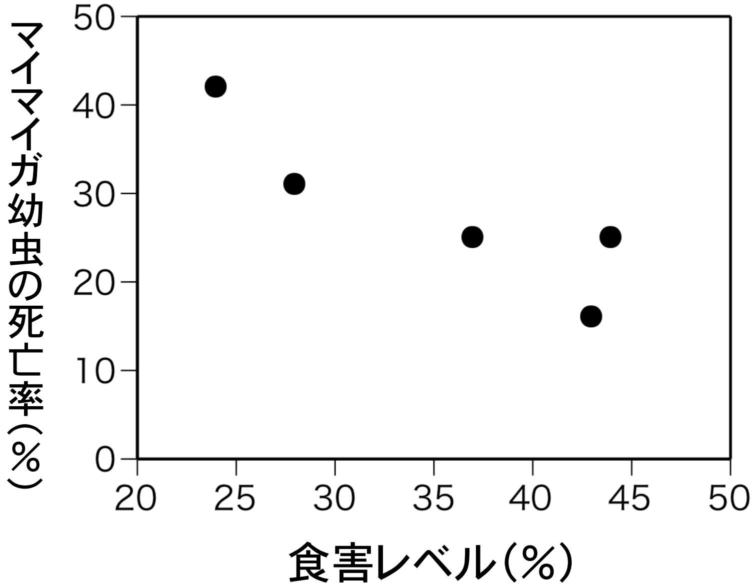
Faeth (1986)

3栄養段階間の相互作用(4)







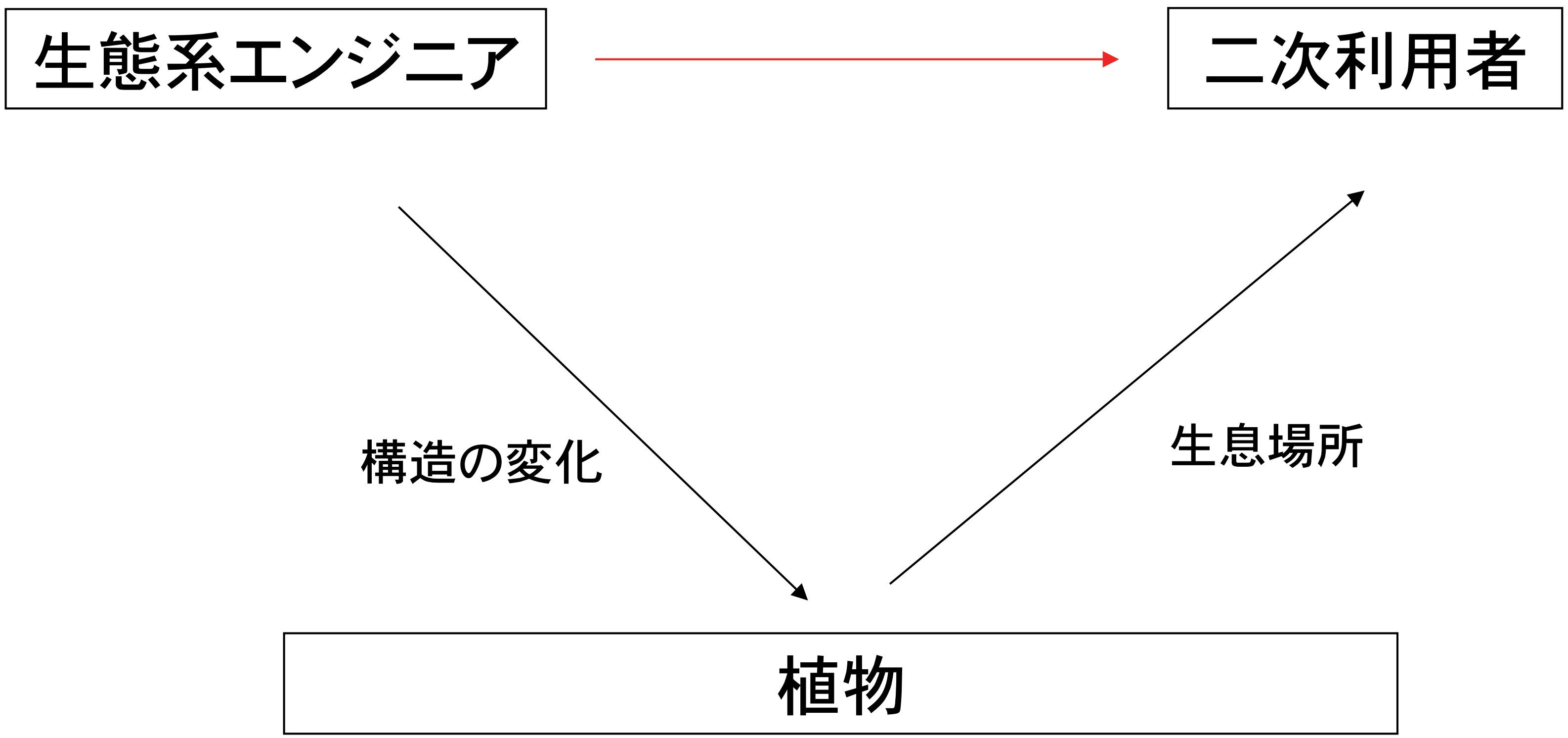


Hunter and Schultz (1993)

植物―植食者―捕食者の相互作用

- 植物形質の変化が、植食者を通して、捕食者に影響する
  - 誘導防衛反応
    - 昆虫の発育が遅延する（捕食機会の増加）
    - 昆虫の移動を活発化させる（捕食機会の増加）
    - 昆虫の病気に対する抵抗性が低下する
- 植物形質の変化が、捕食者（寄生者）を通して、植食者に影響する
  - 二次代謝物質・揮発性成分・花外蜜に対する捕食者の反応
    - 二次代謝物質・揮発性物質が餌の植食者を見つける手がかり
    - 花外蜜によるアリの誘導
  - 防衛物質が植食者の病原菌に負の影響を与える
    - 感染率の低下

生態系エンジニアが誘導する間接効果

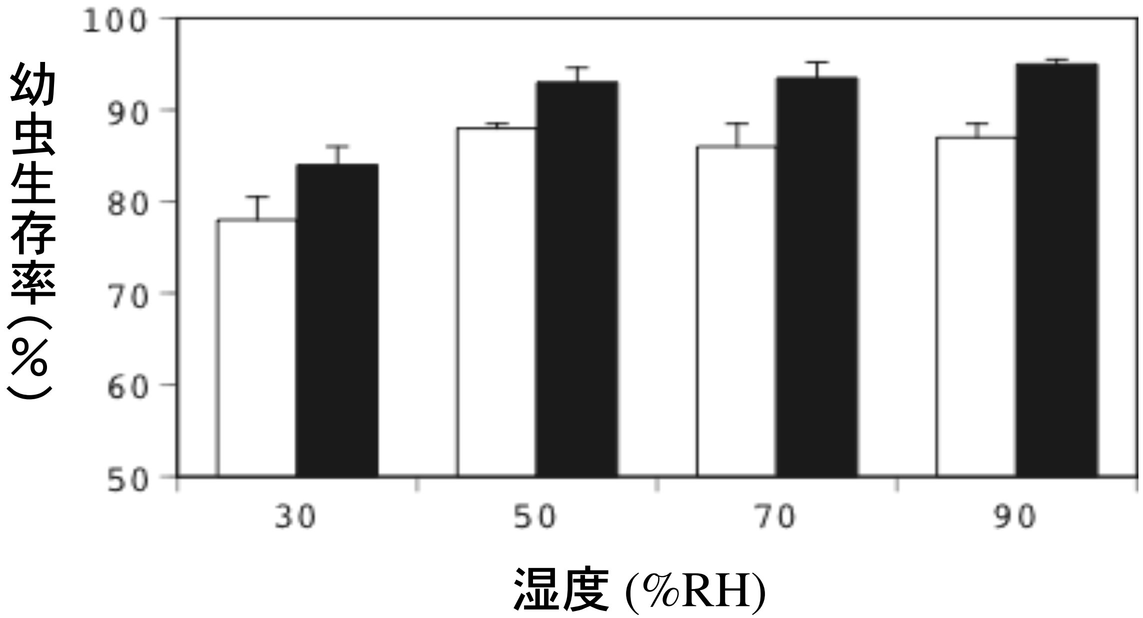


なぜ二次利用するのか?

- 避難場所(シェルター)としての役割
  - 天敵を避ける
  - 不適な環境条件(乾燥、高温)を避ける
- 食物資源としての役割
  - 防衛形質の低下
  - 質の向上
- 構造物の作成にかかるコストを避ける

シェルターとしての役割

Galerucella lineola on
Salix viminalis



Larsson et al. 1997

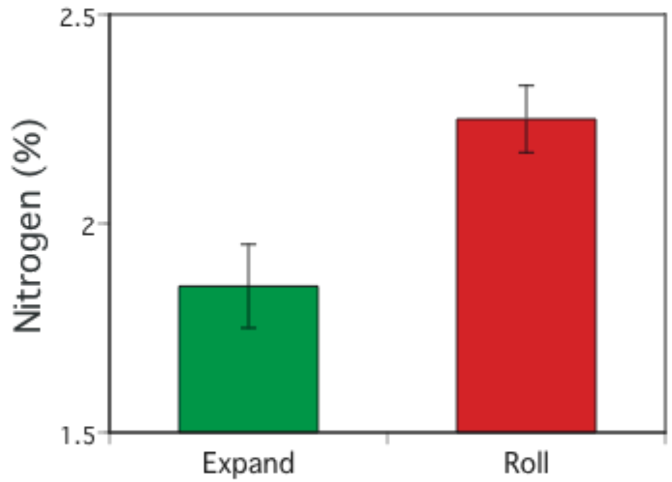
食物資源としての役割(1)

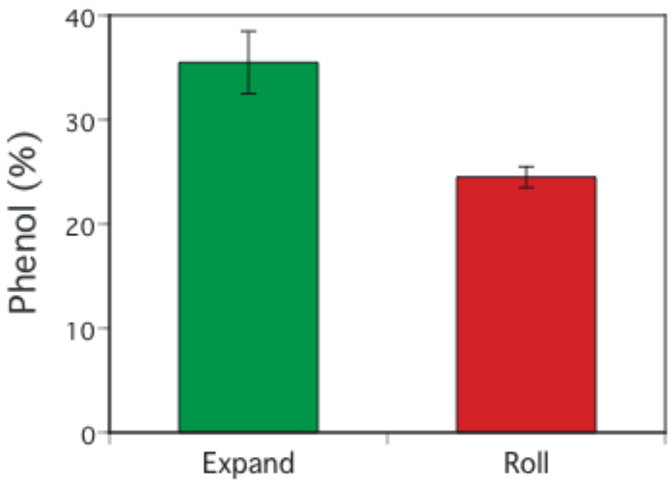
	葉巻	コントロール	P
含水率 (%)	74.0	76.0	NS
窒素 (mg g^{-1} DW)	29.8	32.2	NS
硬さ (g)	90.9	130.7	**
タンニン (mg g^{-1} FW)	136.5	160.3	*
選好性 (no. of caterpillars)	9	0	**

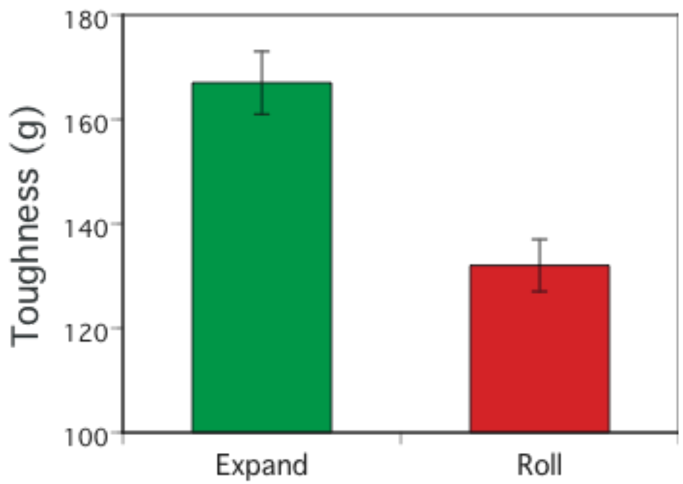
Psychotria horizontalis (Rubiaceae) アカネ科

Sagers (1992)

食物資源としての役割(2)

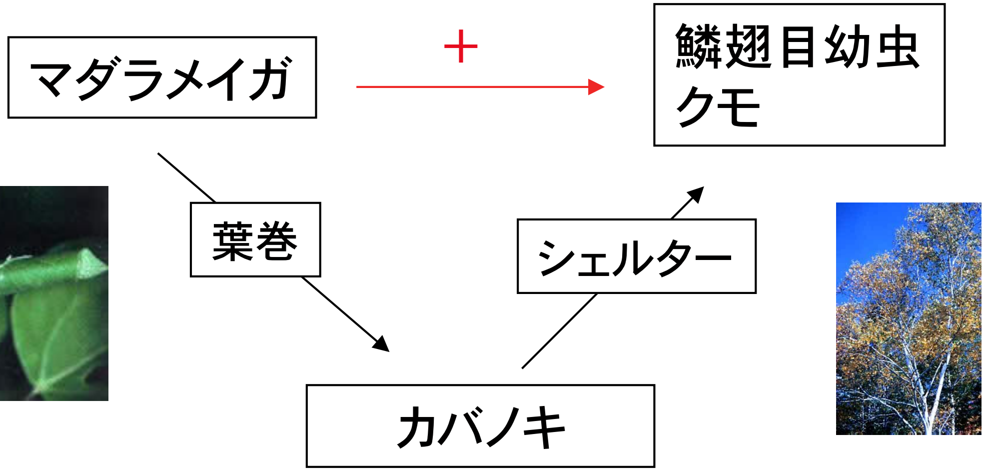


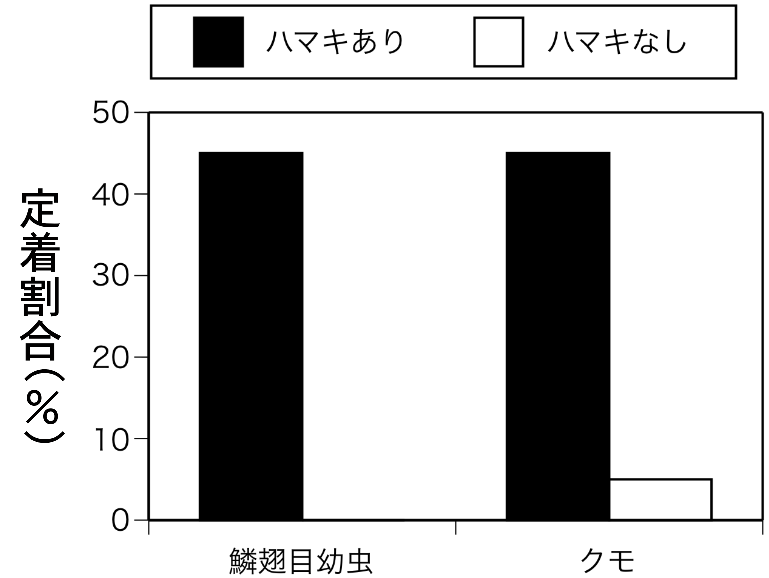


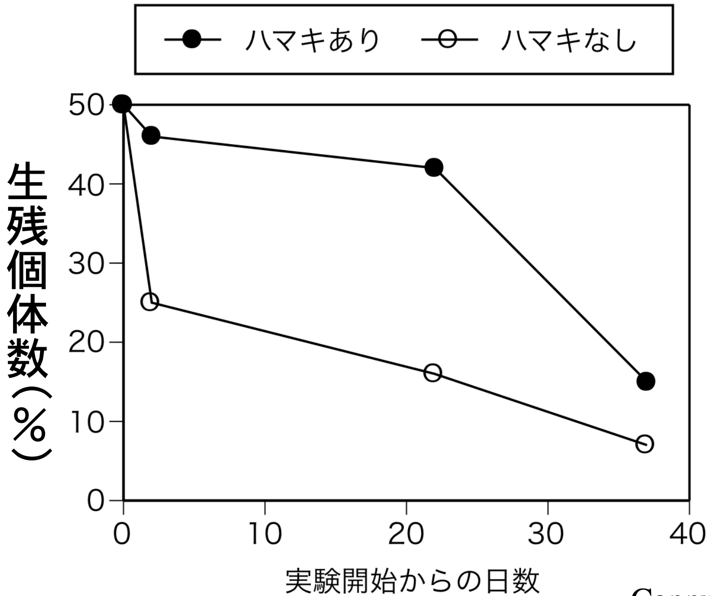


Fukui et al. (2002)

シェルターを介した相互作用





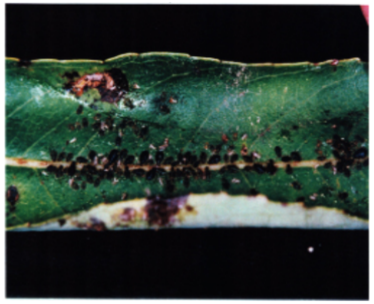


Cappuccino (1993)

葉巻の二次利用者

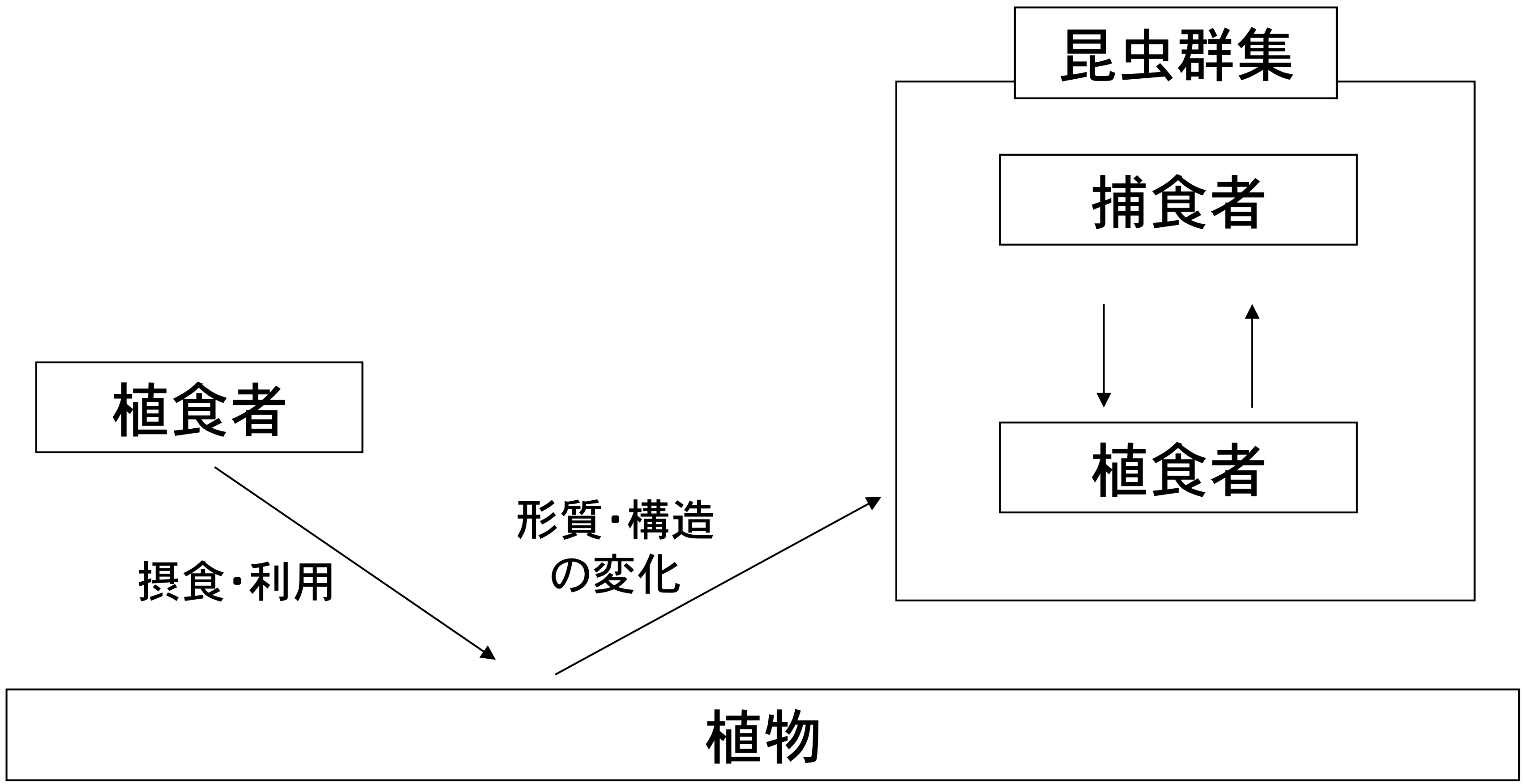
Table 1. Number and proportion of each occupant found in sampled leaf-shelters
(Number of sampled leaf-shelters =1300)

Order		Species	Number	Proportion (%)
Homoptera	Aphid		7481	94.44
		Chaitophorpus saliniger		
Hymenoptera	Ant		394	0.05
		Camponotus japonicus		
		Lasius hayashi		
		Myrmica jessensis		
Hemiptera	Stinkbug		17	＜0.01
Coleoptera	Weevil		15	＜0.01
Dermaptera	Earwig		4	＜0.01
Neuroptera	Lace-winged fly		2	＜0.01
Arachnida	Spider		14	＜0.01
Total			7927	

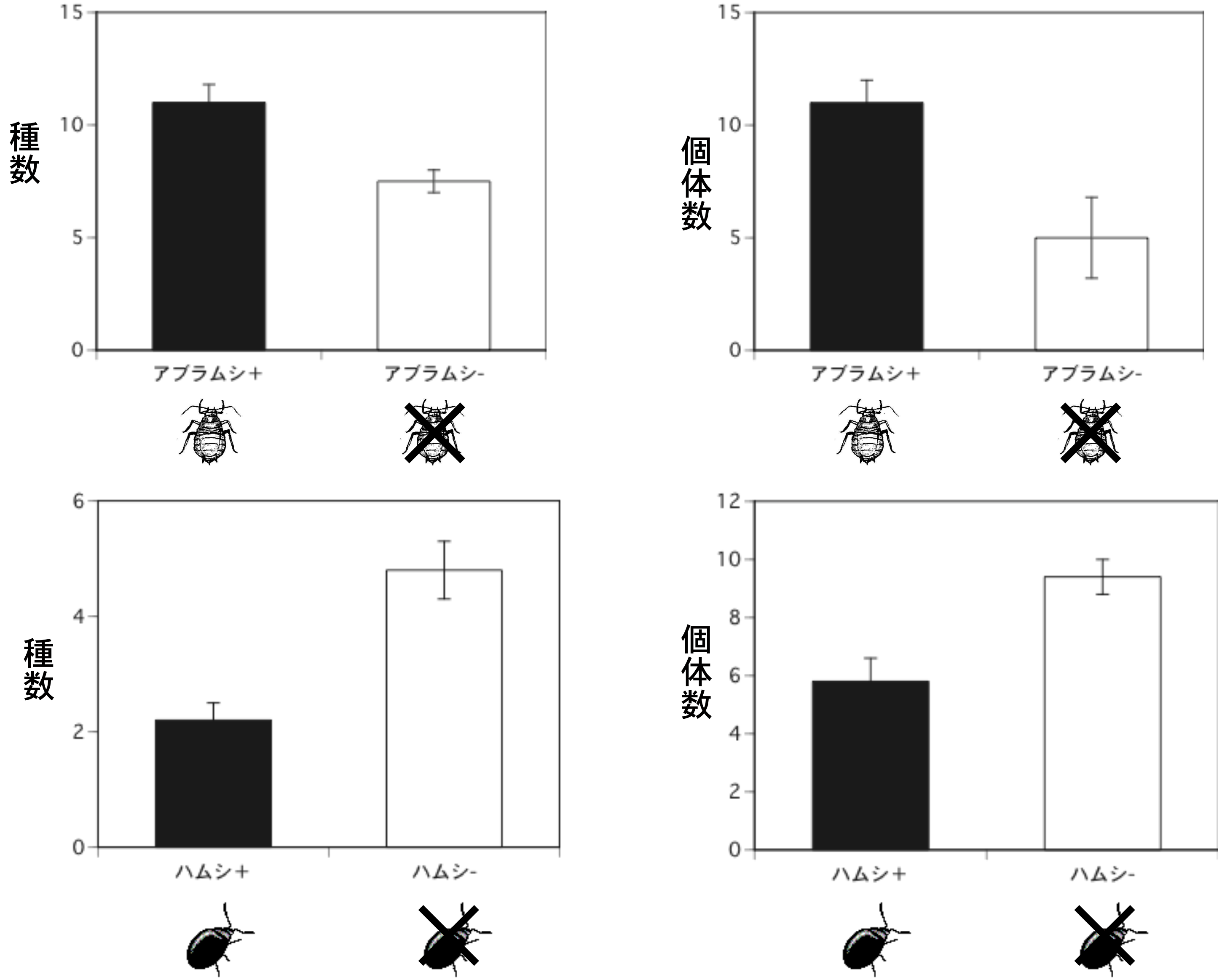


Nakamura and Ohgushi (2004)

昆虫群集に対する影響

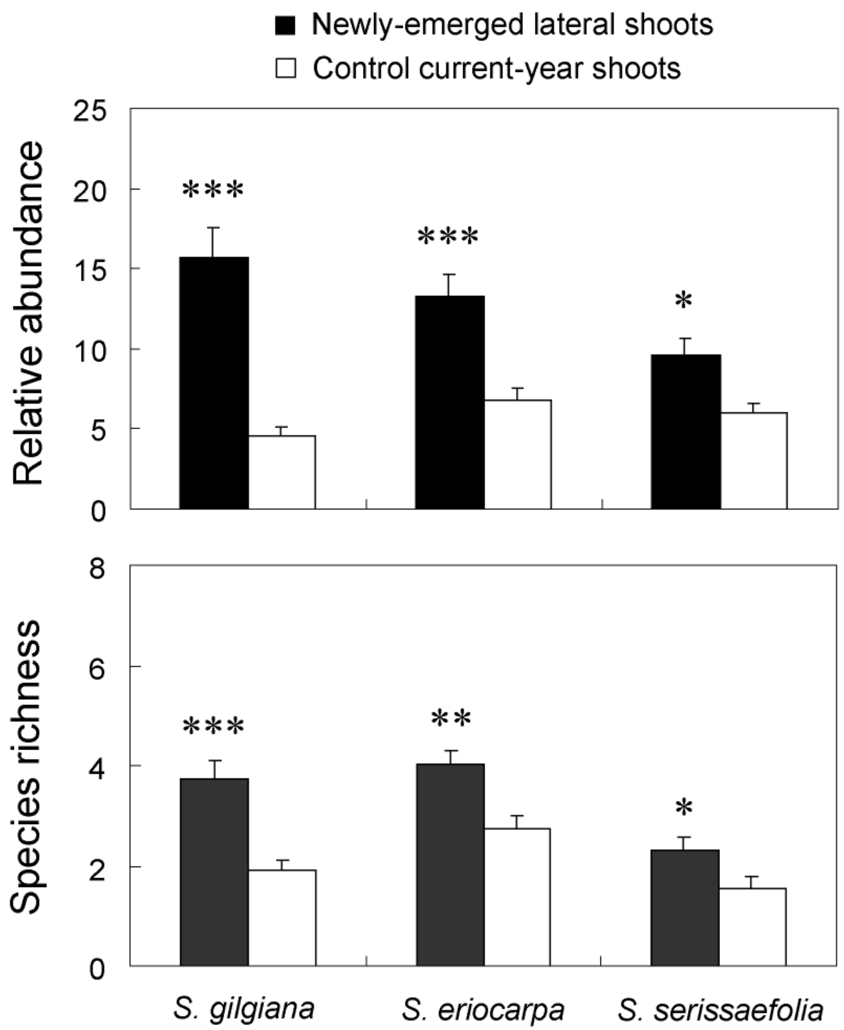


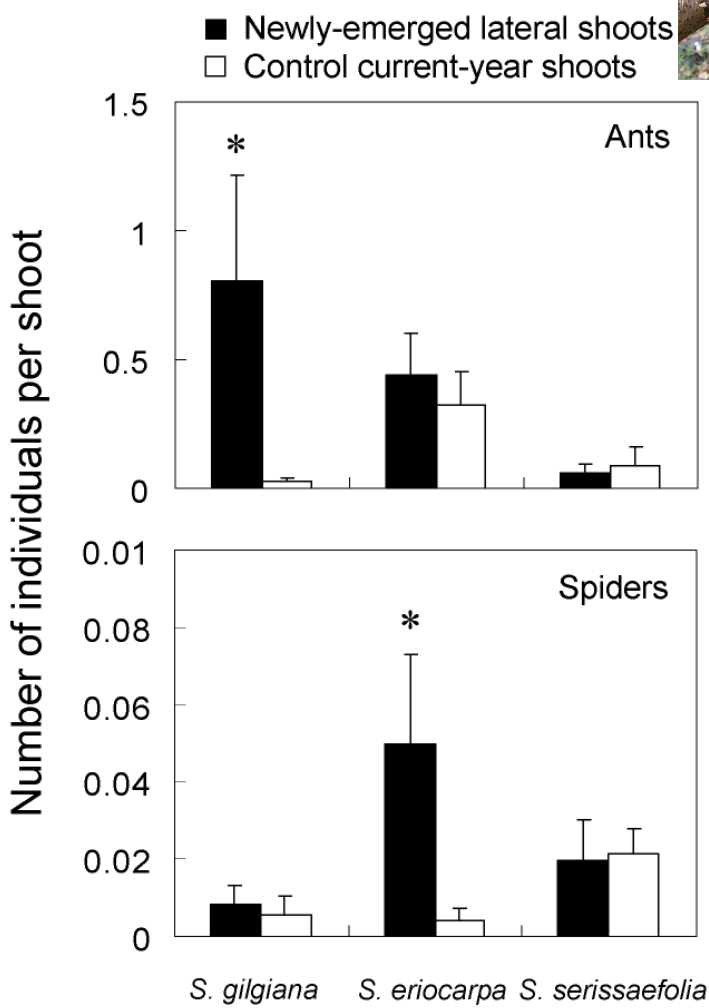
植食者が群集に与える影響(1)



Waltz and Whitham (1997)

植食者が群集に与える影響(2)



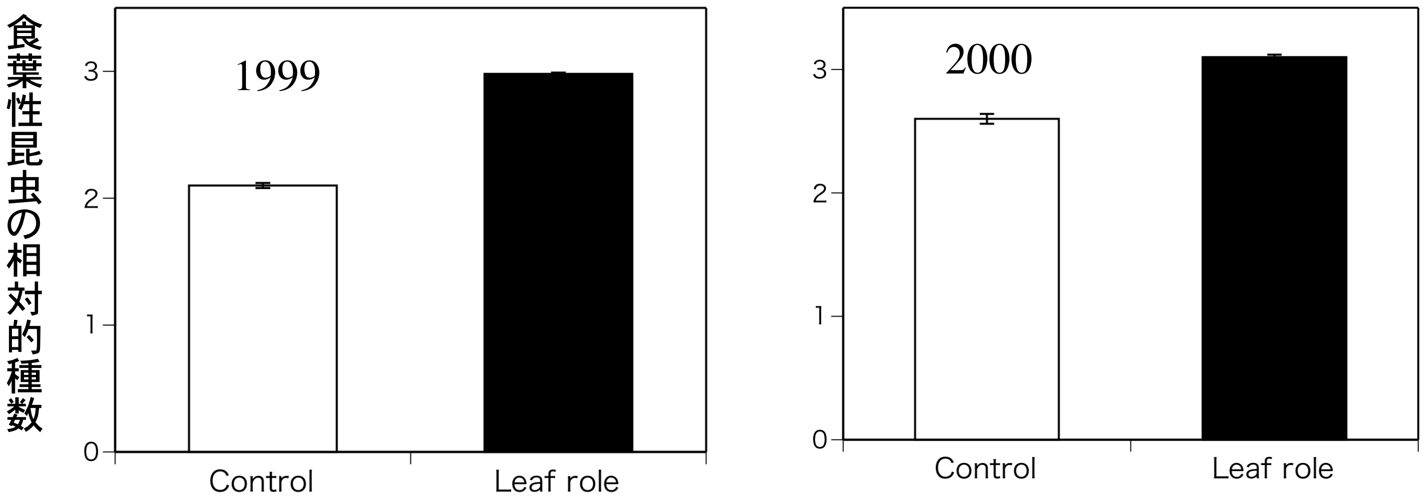


Utsumi and Ohgushi (2009)

生態系エンジニアが群集に与える影響(1)

White oak, *Quercus alba*

Leafroller, *Pseudotelphusa* sp.
(Gelechiidae)

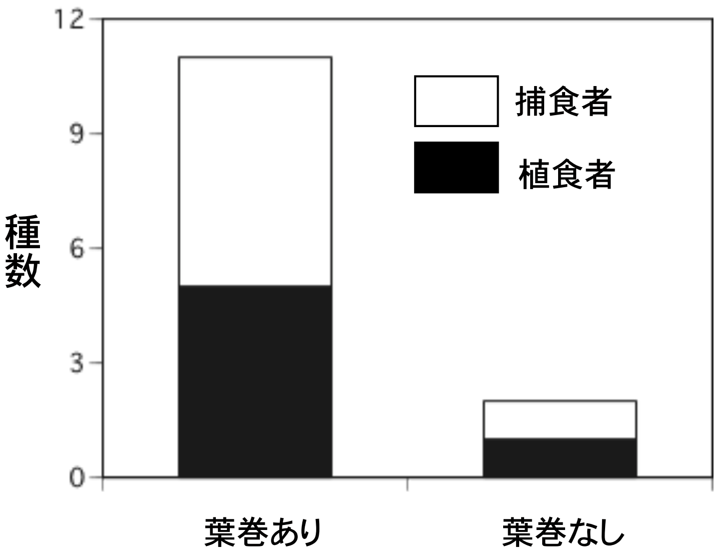


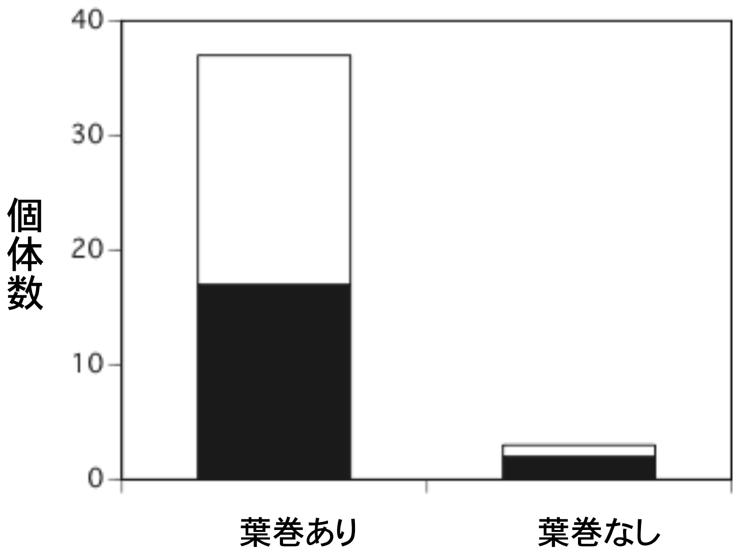
Lill and Marquis (2003)

生態系エンジニアが群集に与える影響(2)

ハコヤナギ, *Populus fremontii* x *P. angustifolia*

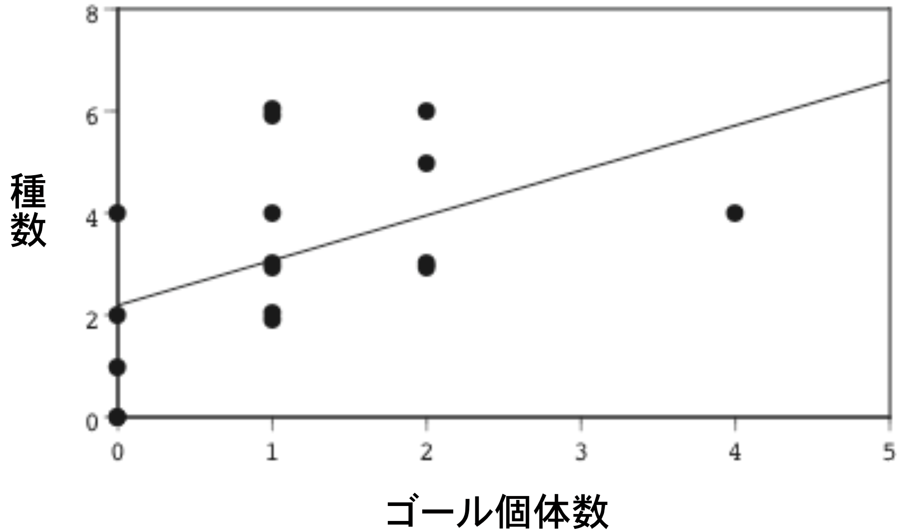
Leafrolls by *Anacampsis niveopulvella* (Gelechiidae)

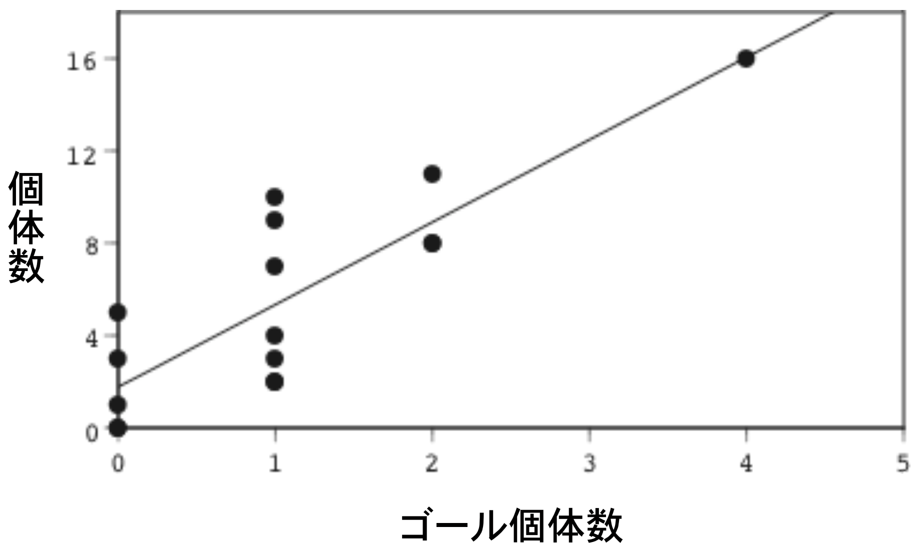




Martinsen et al. (2000)

生態系エンジニアが群集に与える影響(3)





ハコヤナギ, *Populus tremuloides*

ハバチのゴール, *Phyllocolpa bozemanii*

Bailey and Whitham (2003)

植物上の生態系エンジニアの機能

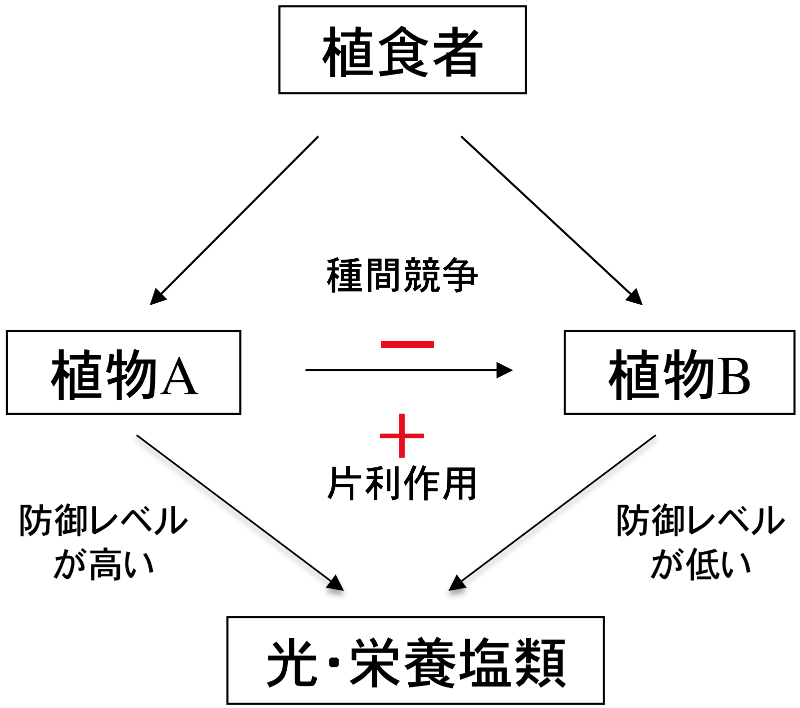
- 生物間相互作用
  - 植物の構造の改変による間接効果
  - 栄養（食う食われる）関係
    - 植食者間
    - 植食者と捕食者
  - 二次利用者に対してプラスの効果
  - 相互作用の多様性を増やす
- 節足動物群集
  - 個体数・種数・種構成を変える

生物群集を変える植物形質と生態系エンジニア

- 植物形質の変化
  - 防衛化学物質(二次代謝物質)
  - 物理的防御形質(トリコーム、棘、葉の硬さ)
  - 栄養(窒素、リン)
  - 補償反応(構造)
  - 揮発性物質
  - 花外蜜
- 生態系エンジニアによる構造の変化
  - ハマキ、ゴール、穿孔、潜葉

陸上生態系では普遍的!

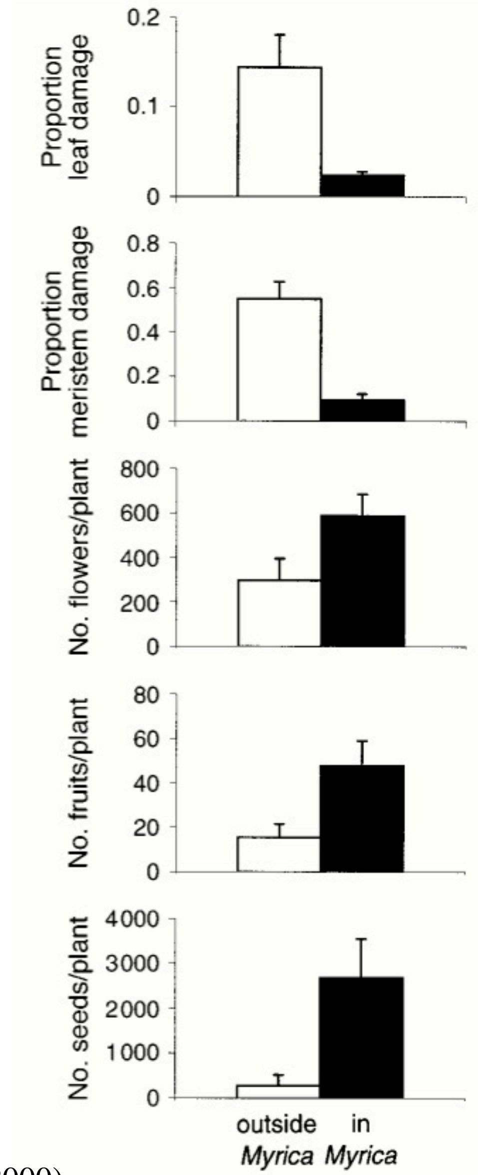
植物種間の間接相互作用



Associational resistance

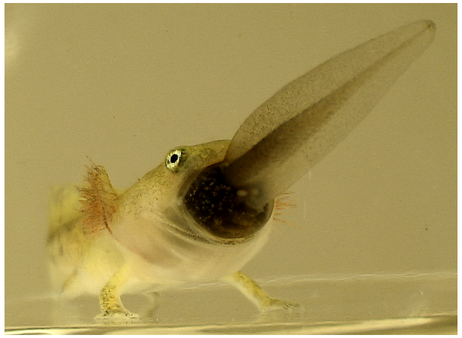
ヤチヤナギ

エゾミソハギ



Hämback et al. (2000)

捕食ー被食関係での防衛形態の誘導


植物の誘導防衛との違いは?

寄生者ー寄主の相互作用系

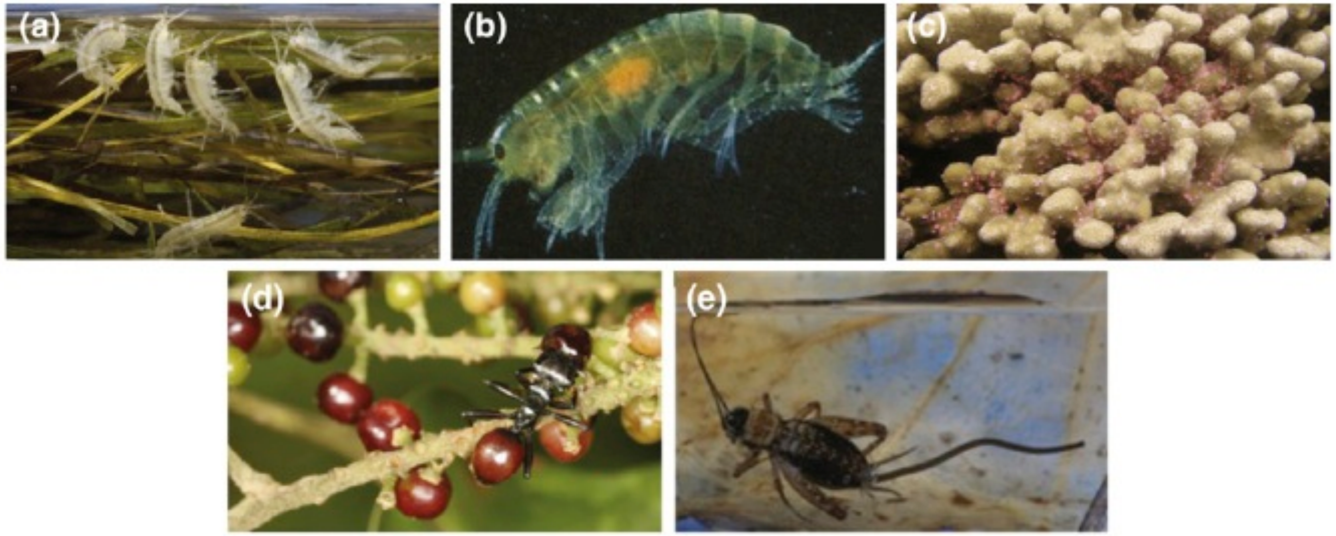


Figure 1. Examples of manipulative parasites. **(a)** The crustacean amphipod *Gammarus insensibilis* manipulated by the trematode *Microphallus papillorobustus* (photo by P. Goetgheluck); infected gammarids display a positive phototactism, a negative geotactism and an aberrant evasive behaviour. Indeed, instead of hiding under stones, they swim toward the surface, and are preferentially eaten by aquatic birds (definitive hosts) [59]. **(b)** Cystacanth of *Polymorphus minutus* (Acanthocephalan) encysted in the body cavity of *Gammarus pulex* [49] (photo by F. Cezilly). Unlike *M. papillorobustus*, which is encysted in the brain of the gammarid (in (a)), the acanthocephalan is encysted in the body cavity in (b). Remarkably, this acanthocephalan also ends its life cycle in an aquatic bird and induces similar behavioural changes in the gammarid. Because trematodes and acanthocephalans are phylogenetically distant, this illustrates a case of evolutionary convergence in the manipulative process. **(c)** Coral polyps infected with a trematode (*Podocotyloides stenometra*). The parasite induces pink, swollen nodules on the coral colony and impairs their retraction ability. Infected polyps are, therefore, both conspicuous and vulnerable to predation by the coral-feeding butterflyfish *Chaetodon multicinctus* (the parasite's definitive host) [60] (photo by G. Aeby). **(d)** An ant (*Cephalotes atratus*) parasitised by a nematode (*Myrmeconema neotropicum*). The parasite induces fruit mimicry and modifies the ants' behaviour, making them more likely to be ingested by fruit-eating birds (final hosts) [61] (photo by S.P. Yanoviak). **(e)** The Gordian worm (*Paragordius tricuspidatus*) exiting the body of a cricket (*Nemobius sylvestris*) (photo by P. Goetgheluck). Mature worms manipulate cricket behaviour, causing them to jump into water. Once emerged, the parasite swims away to find a mate [62].

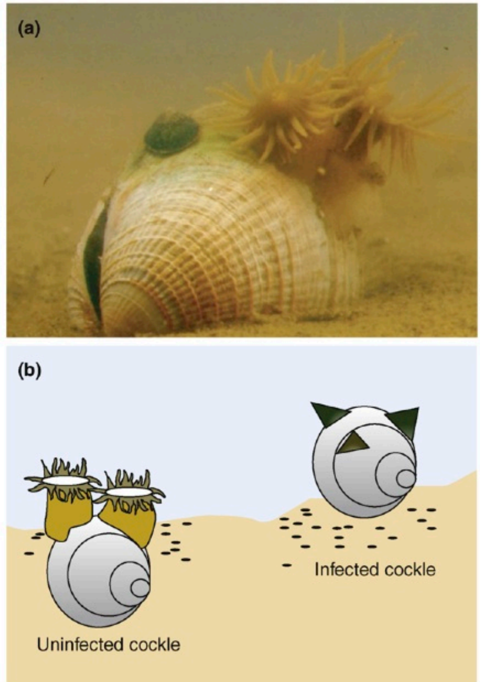


Figure I. Interactions between cockles, trematodes and sessile invertebrates. **(a)** The cockle *Austrovenus stuchburyi* with the two most common invertebrate species living on its shell, the limpet *Notoacmea helmsi* and the anemone *Anthopleura aureodiata*. **(b)** Schematic representation of habitat creation by manipulative parasites.

寄生者による寄主の操作
（Parasite manipulation）