EXPLOITATION: PREDATION, HERBIVORY, PARASITISM, AND DISEASE

Chapter 14 (2)

Molles2005, Townsend et al. 2003, Krohne 2001

Chapter Concepts

IV. Population dynamics: Predator-prey, host-parasite, and host-pathogen relationships are dynamic.

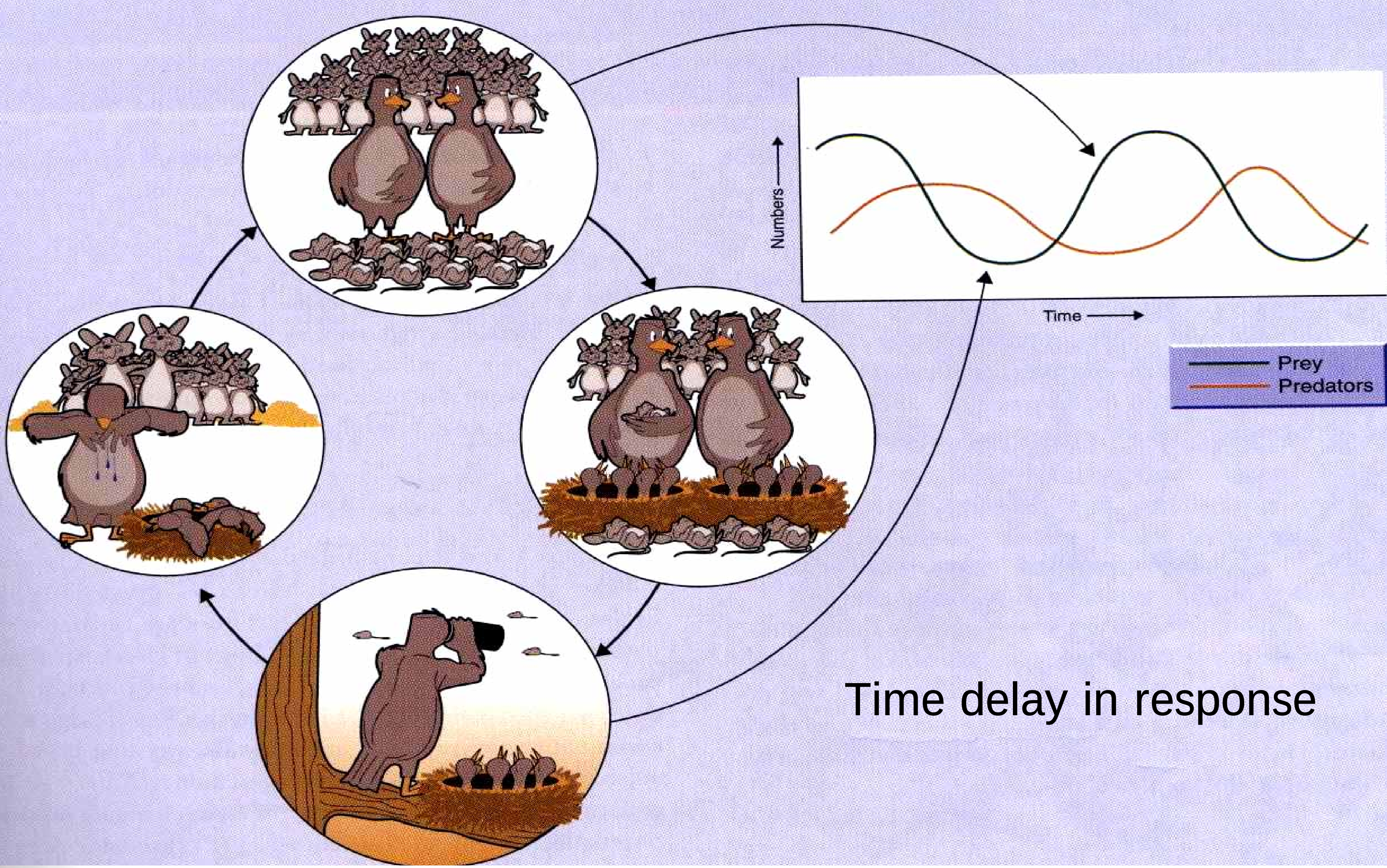


Figure 8.13

The underlying tendency for predators and prey to display coupled oscillations in abundance as a result of the time delays in their responses to each other's abundance.

Model Behavior

- Host exponential growth often opposed by exploitation.
  - Host reproduction immediately translated into destruction by predator.
  - Increased predation→ more predators.
  - More predators → higher exploitation rate.
  - Larger predator pop. eventually reduces host population, in turn reducing predator pop.

Model Behavior

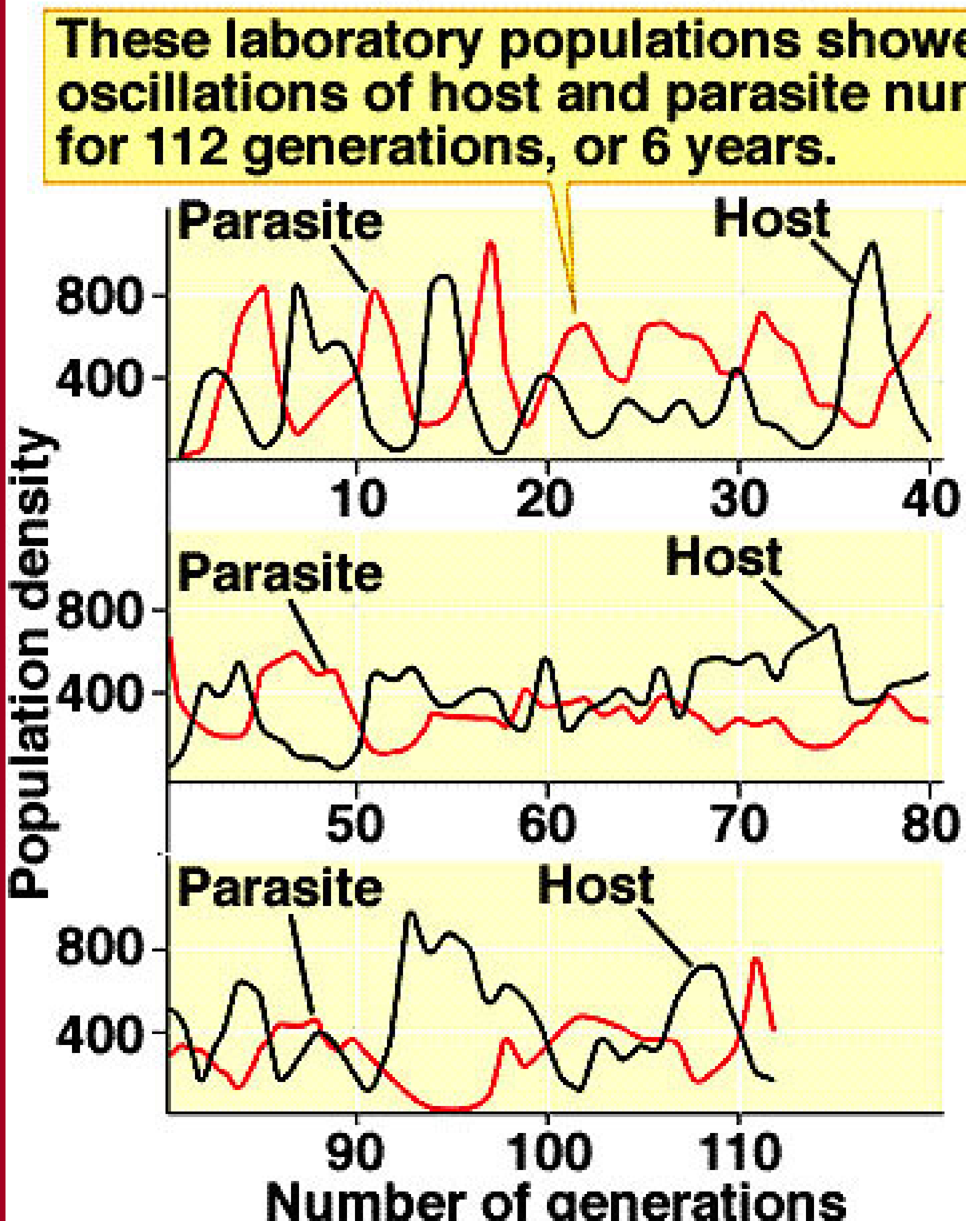
- Reciprocal effects produce oscillations in two populations.

  - Although the assumptions of eternal oscillations and that neither host nor exploiter populations are subject to carrying capacities are unrealistic, L-V models made valuable contributions to the field.

Laboratory Models

- *Utida* found reciprocal interactions in adzuki bean weevils *Callosobruchus chinensis* over several generations.
- *Gause* found similar patterns in *P. aurelia*.

Populations of Parasite & Host



Adzuki bean weevil & a parasitoid wasp

✳ Population dynamics

- Lotka-Volterra Predator-Prey model
  - ❖ Predator-prey cycles (theory, practice)
- Transmission model for microparasites (Disease dynamics)
- Other factors influence P-P cycles

Lotka-Volterra Model

For Prey (N)

$$dN/dt = rN - aPN$$

For Predator (P)

$$dP/dt = faPN - qP$$

a: attacking efficiency, *q*: mortality rate
f: pred efficiency at turning this food into pred offspring

Population Cycles in Mathematical model

- Lotka Volterra assumes **host** pop. grows at exponential rate and pop. size is limited by parasites, pathogens, and predators:

$$dN_h/dt = r_h N_h - pN_h N_p$$

- $r_h N_h$ = exponential growth by host population.
  - Opposed by:
    - P = rate of parasitism / predation.
    - N_h = Number of hosts.
    - N_p = Number of parasites / predators.

Population Cycles in Mathematical model

- Lotka Volterra assumes **parasite/predator** growth rate is determined by rate of conversion of food into offspring minus mortality rate of parasitoid population:

$$dNp/dt = cpN_hN_p - d_pN_p$$

- cpN_hN_p = conversion rate of hosts into offspring
- pN_hN_p = rate at which exploiters destroy hosts
- C = conversion factor

Prey Zero Isocline

$$dN/dt = rN - aPN = 0$$

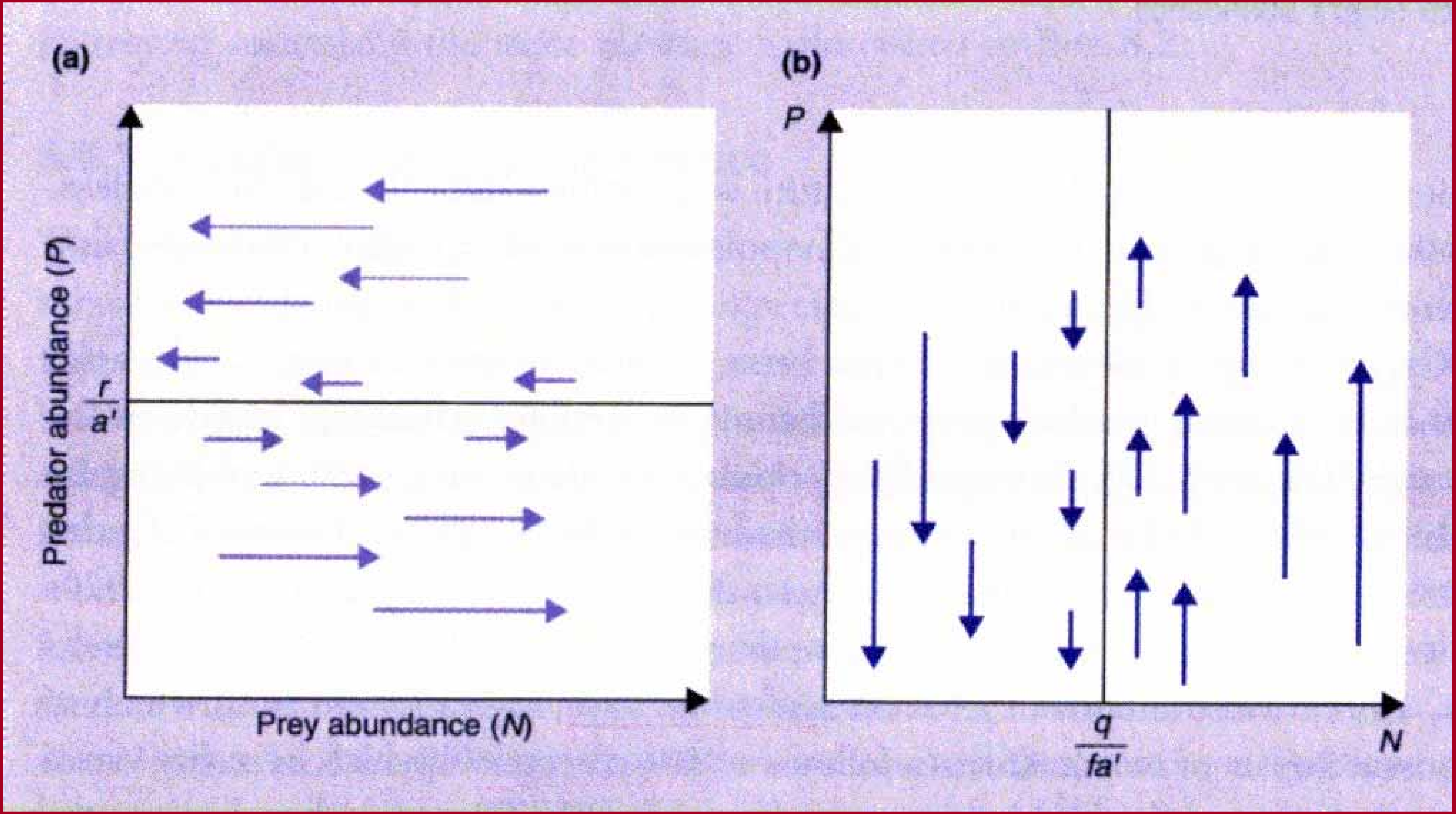
$$\rightarrow P = r/a$$

Predator Zero Isocline

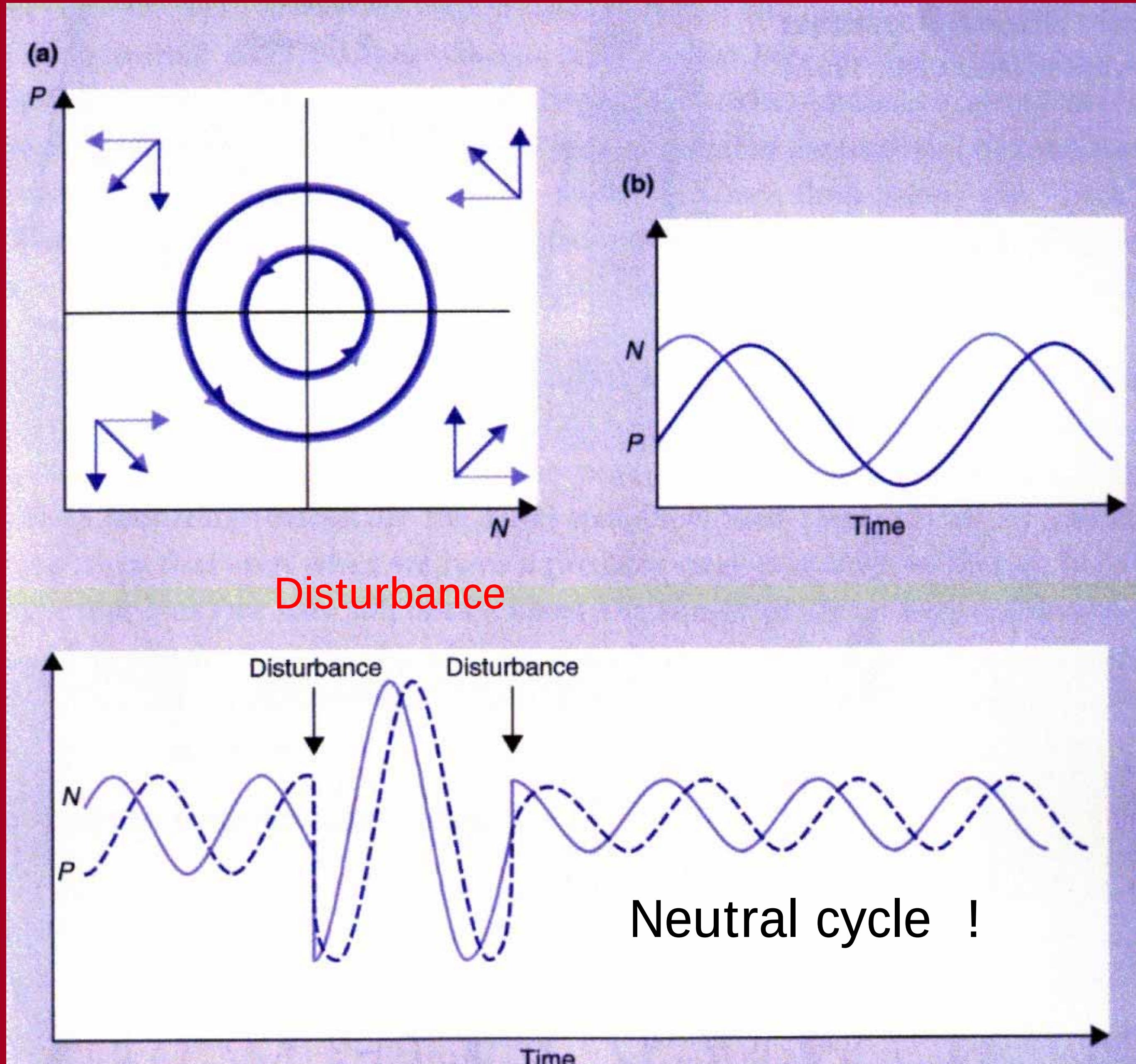
$$dP/dt = faPN - qP = 0$$

$$\rightarrow faN - q = 0$$

$$\rightarrow N = q/fa$$



(a)
Predator abundance (P)
r
a'
Prey abundance (N)
(b)
P
N
q
fa'



(a)
P
N
(b)
N
P
Time
Disturbance
Disturbance
Disturbance
N
P
Neutral cycle !
Time

Disease Transmission Model

$$R_p = SBL$$

If R_p <1, infection will die,
if R_p >1, infection will spread

R_p=reproductive rate= the average no. of new infected hosts which arise from an infectious host

S = no. susceptible individuals

B = transmission rate

L = infectious time period

Transmission Threshold

$$R_p = 1 = SBL$$

Threshold Pop size

$$S_\tau = 1/BL$$

Ex. Measles need 300,000 ind,
Epidemic in cities

Disease cycles

- A sequence:

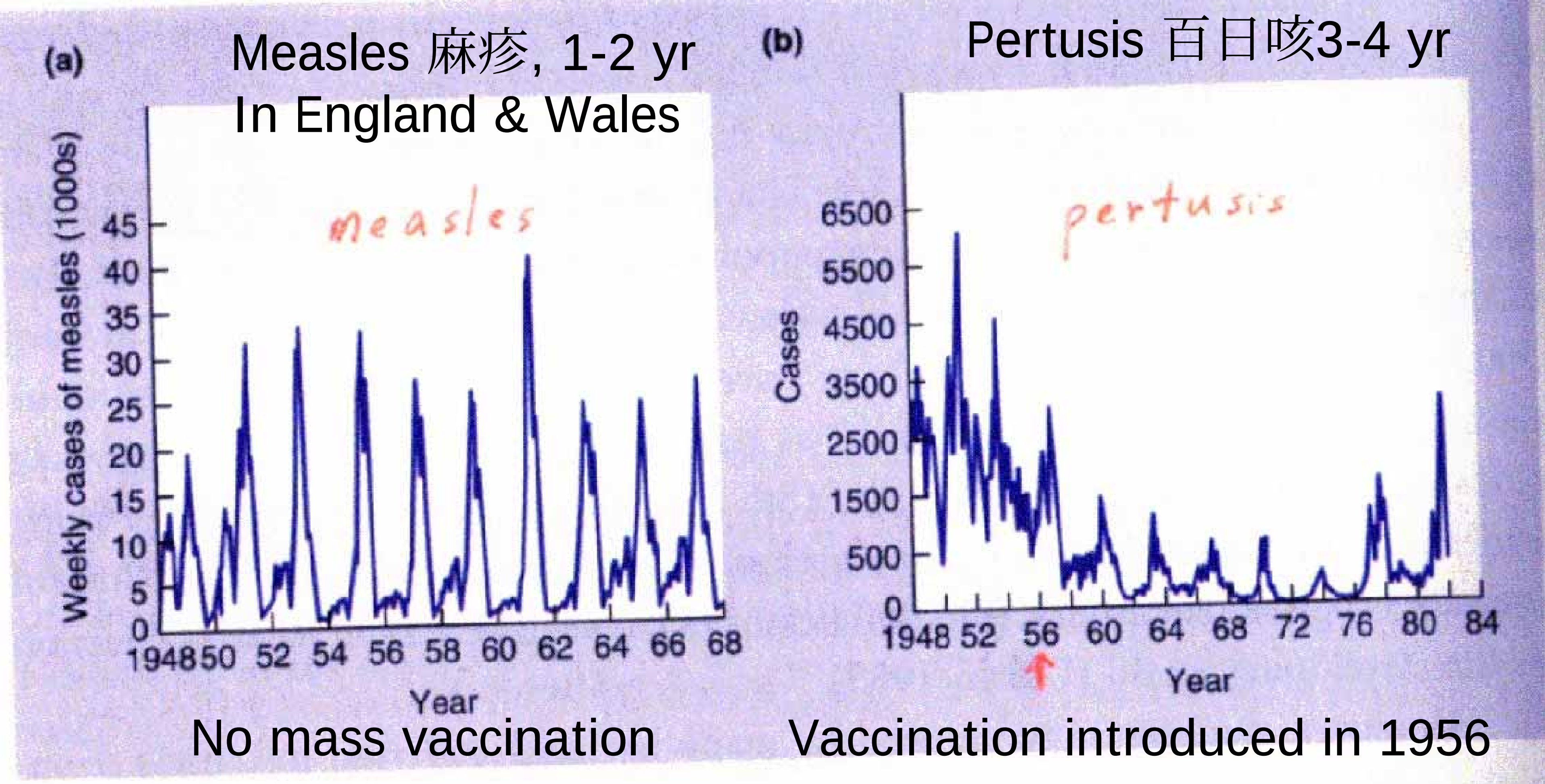
  High incidence→ few susceptibles →

  → low incidence→ many susceptibles→high incidence, *etc*.
- Just like other P-P cycles

Disease cycles

Measles 麻疹, 1-2 yr
In England & Wales

Pertusis 百日咳3-4 yr



No mass vaccination

Vaccination introduced in 1956

Chapter Concepts

V. * **Stability** of P-P/H dynamics: (To persist in the face of exploitation, hosts and prey need refuges. In Molles)

- Carrying capacity of both Ps
- Allee effect of prey
- Crowding of Predator
- Patchy distribution & metapopulation
- Refuge effect of prey

Carrying capacity

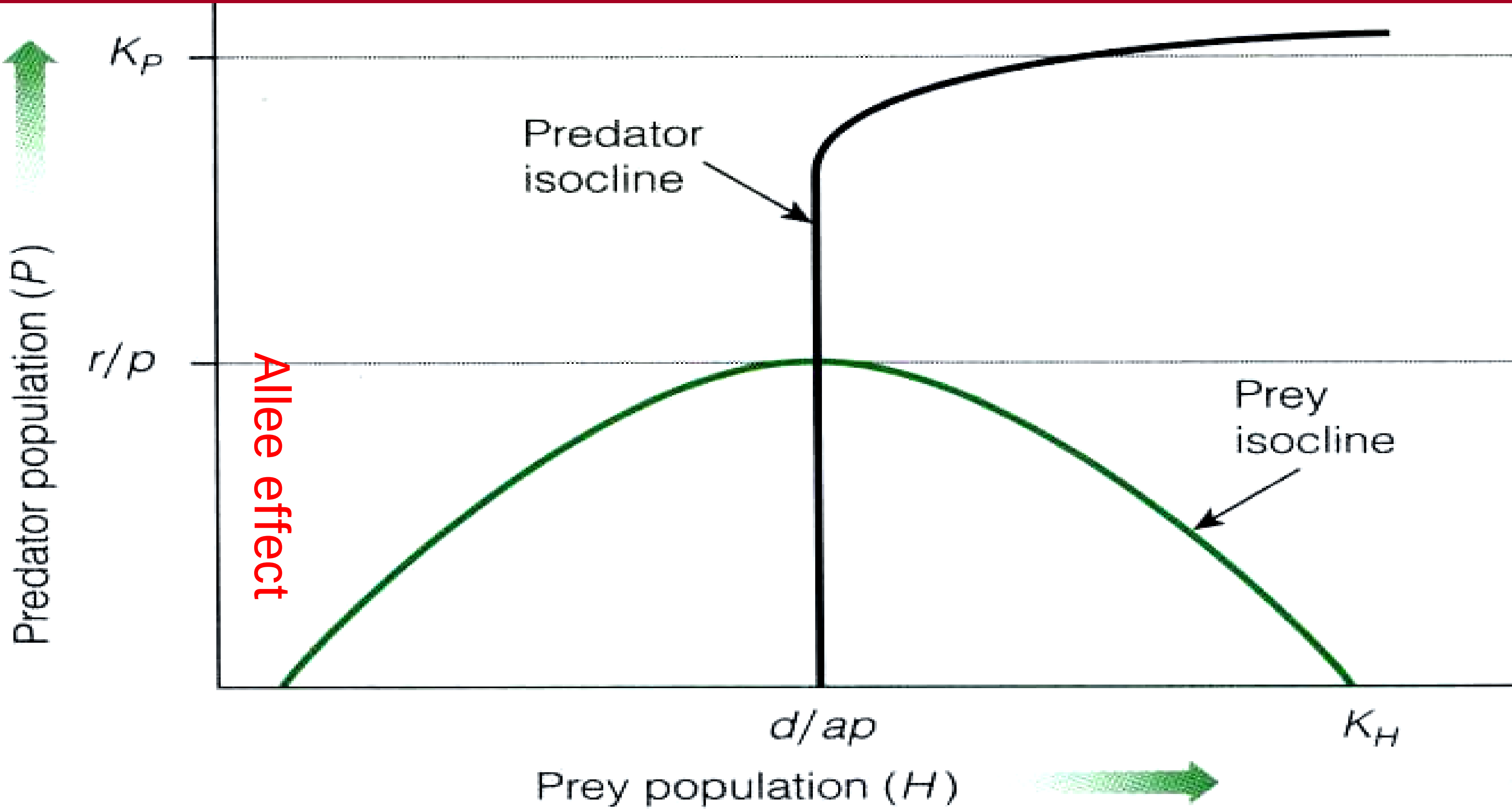


FIGURE 10.21 The predator–prey model with modified isoclines to account for predator and prey carrying capacities and for the Allee effect for small prey populations.

- Allee effect, in which population growth rate is negative at low population densities. For a pop like this, extinction is likely when the pop falls below some threshold low density. (Krohne 2001)

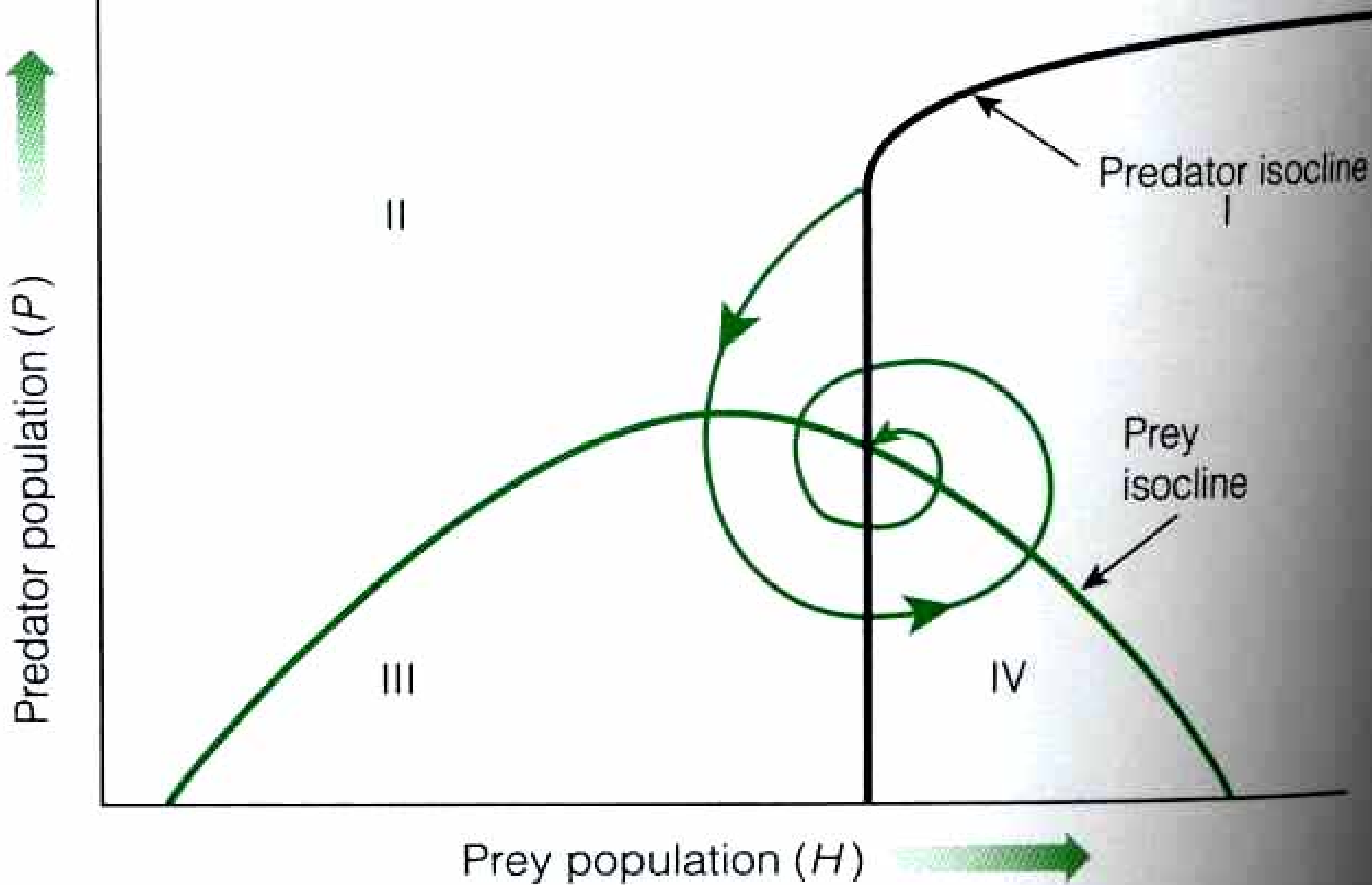


FIGURE 10.23 The trajectory of predator and prey populations when the predator isocline is to the right of the prey isocline hump. The result is coexistence of the two populations.

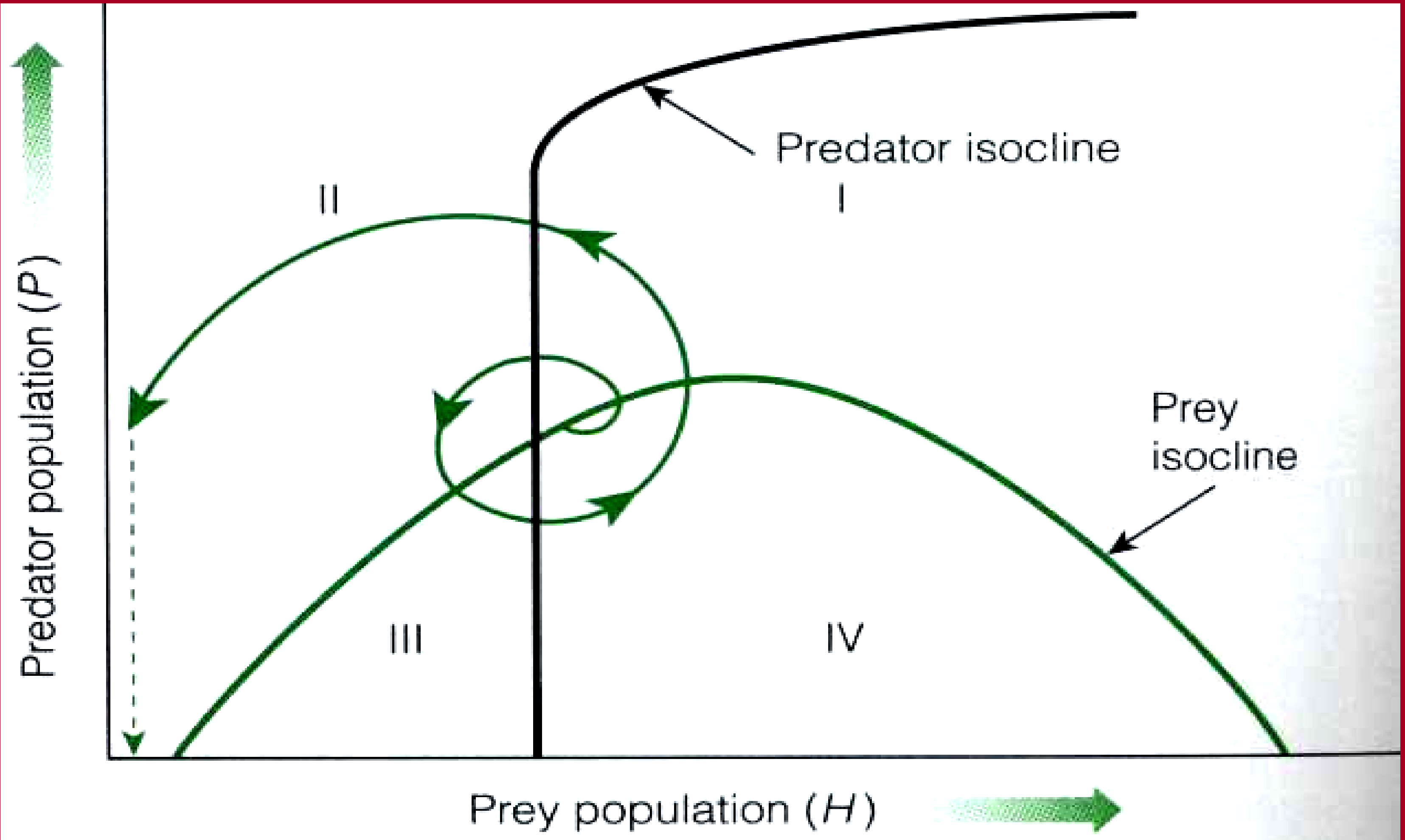


FIGURE 10.22 The trajectory of predator and prey populations when the predator isocline is to the left of the prey isocline peak. The eventual effect is the extinction of the prey population.

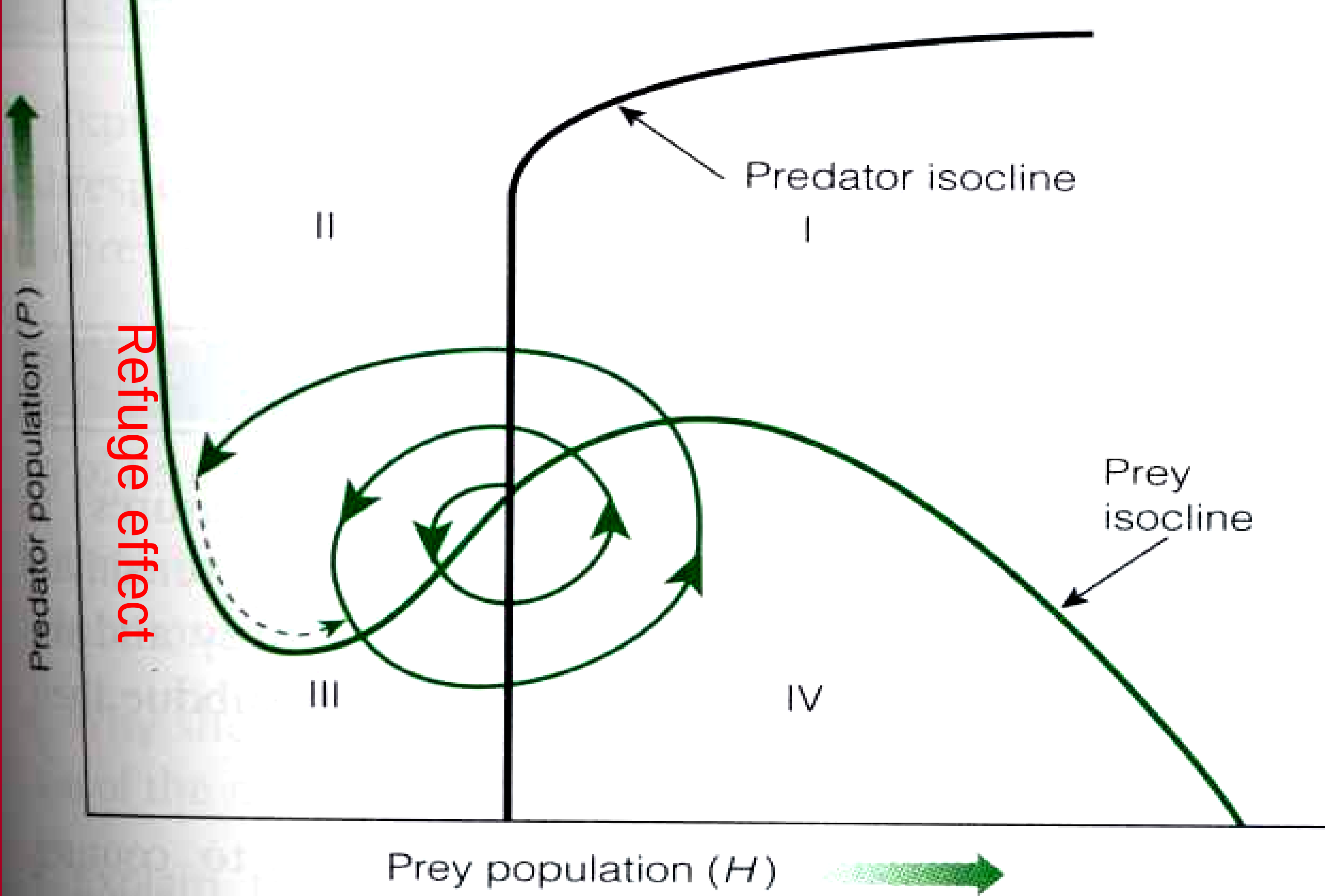


FIGURE 10.24 The trajectory of predator and prey populations when the prey items have a refuge where they can avoid predation. Even when the predator isocline is to the left of the prey hump, coexistence of predator and prey populations results.

Crowding effect

(=density-dependent effect

→mutual interference among predators

→reduces the predation rate)

➔Stablelizing effect

(dampen or eliminate P-P cycles)

Either for true predator or parasite

- Refuge effect on P-P cycles
  - In space
  - In number
  - By Predator satiation
  - By relative size

Refuges

- To persist in the face of exploitation, hosts and prey need refuges.
- *Gause* attempted to produce population cycles with *P. caudatum* and *Didinium nasutum.*
  - *Didinium* quickly consumed all *Paramecium* and went extinct. (Both pops. Extinct)
    - Added sediment for *Paramecium* refuge.
      - Few *Paramecium* survived after *Didinium* extinction.

Refuges

- *Huffaker* studied six-spotted mite *Eotetranychus sexmaculatus* and predatory mite *Typhlodromus occidentalis.*
  - Separated oranges and rubber balls with partial barriers to mite dispersal.
  - *Typhlodromus* crawls while *Eotetranychus* balloons.
  - Provision of small wooden posts to serve as launching pads maintained population oscillations spanning 6 mos.

Protection In Numbers

- Living in a large group provides a "refuge."
- Predator's response to increased prey density:

$$\frac{\text{Prey consumed}}{\text{Predator}} \times \frac{\text{Predators}}{\text{Area}} = \frac{\text{Prey Consumed}}{\text{Area}}$$

- Wide variety of organisms employ predator satiation defense.
  - Prey can reduce individual probability of being eaten by living in dense populations.

Predator Satiation by Periodical Cicadas

- Periodical cicadas *Magicicada spp.* emerge as adults every 13-17 years.
  - Densities can approach $4x10^6$ ind / ha.
- *Williams* estimated 1,063,000 cicadas emerged from 16 ha study site.
  - 50% emerged during four consecutive nights.
  - Losses to birds was only 15% of production.

Size As A Refuge

- If large individuals are ignored by predators, then large size may offer a form of refuge.
  - *Peckarsky* observed mayflies (Family Ephenerellidae) making themselves look larger in the face of foraging stoneflies.
    - In terms of optimal foraging theory, large size probably equates to lower profitability.

END!