Lady Beetles in Biological Control: Implications of Life History

Scott Smith and Vera Krischik
Department of Entomology
University of Minnesota
St. Paul, MN

Biological control successes*

Success	Aphelinidae	Braconidae	Encyrtidae
Complete	16 (9)	10 (17)	15 (12)
Total	28	54	37
% of grand total	14.1	27.1	18.6

Success	Ichneumonidae	Tachinidae	Coccinellidae
Complete	4 (7)	8 (7)	10 (11)
Total	21	23	36
% of grand total	10.6	11.6	18.1

* world

Hokkannen 1985

Talk components

1) **History of coccinellids in classical biological control**
   From the "lady beetle fantasy" period to the present

2) **Current use of coccinellids**
   Habitats and target prey

3) **Mechanisms of success**
   Why certain successes?

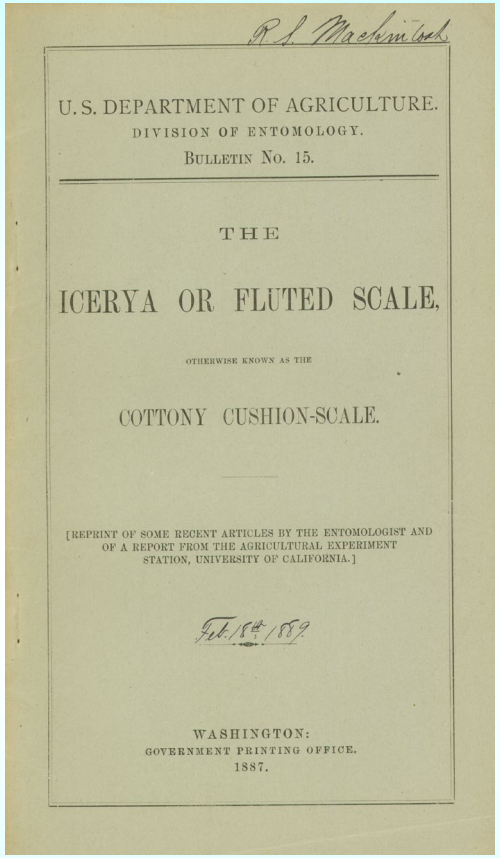
1. History of Coccinellids in Classical BC

Early success influencing perceptions

Rodolia cardinalis
Vedalia beetle

Brand new citrus industry threatened by scale

C.V. Riley sent A. Koebele to Australia



R. L. Machintosh

U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
BULLETIN No. 15.

THE

ICERYA OR FLUTED SCALE,

OTHERWISE KNOWN AS THE

COTTONY CUSHION-SCALE.

[REPRINT OF SOME RECENT ARTICLES BY THE ENTOMOLOGIST AND OF A REPORT FROM THE AGRICULTURAL EXPERIMENT STATION, UNIVERSITY OF CALIFORNIA.]

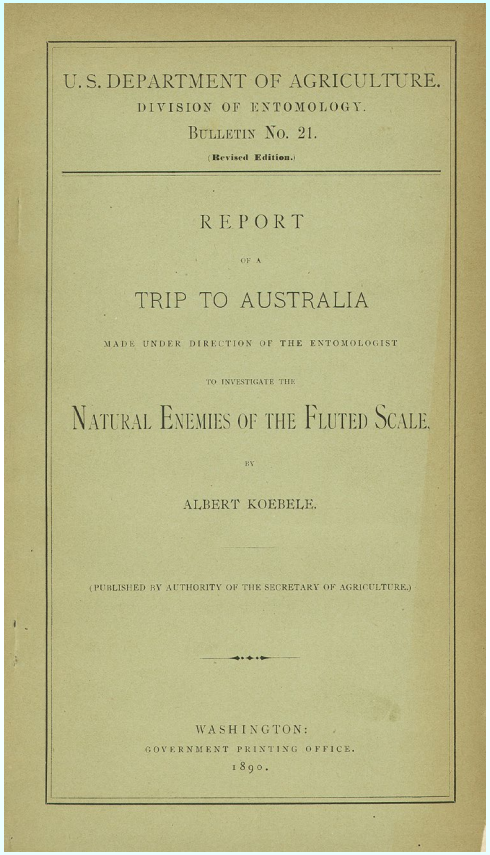
Feb. 18th 1889

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1887.

1888 Koebele sent back 129 individuals

These were caged with an infested citrus tree

Offspring were distributed



U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
BULLETIN No. 21.
(Revised Edition.)

REPORT
OF A
TRIP TO AUSTRALIA
MADE UNDER DIRECTION OF THE ENTOMOLOGIST
TO INVESTIGATE THE
NATURAL ENEMIES OF THE FLUTED SCALE.
BY
ALBERT KOEBELE.

(PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.)

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1890.

Significance of Koebele's introduction

- Ecstatic faith in biocontrol among Californians
- Started the "Lady beetle period"

Significance of Koebele's introduction

- From 1891 to 1892, Koebele sent 4,000 beetles, 40 species, from Austrailasia
- 4 species established

Introduced Coccinellidae in North America

- 179 species intentionally introduced
- 16 established intentionally
- 8 established accidentally

Gordon 1985

Established intentionally

Prey	n	
adelgid	1	balsam wooly adelgid
aphid*	1	aphids in Florida
mite	1	various orchard mites
scales	13	mealybug, scale insects

Gordon 1985

2. Current use of coccinellids in Biocontrol

Habitats and target prey

Family Coccinellidae

Subfamily Sticholotidinae
- Microweisini
- Serangiini
- Cephaloscymnini

Subfamily Scymninae
- Zilini
- Stethorini
- Scymnini
- Selvadiini
- Hyperaspini
- Cryptognathini

Subfamily Chilocorinae
- Chilocorini

Subfamily Coccidulinae
- Coccidulini
- Noviini
- Exoplectrini
- Azyini

Subfamily Coccinellinae
- Coccinellini
- Psylloborini

Subfamily Epilachninae
- Epailachnini

Gordon 1985

Hemiptera: Sternorrhyncha

Superfamily Psylloidea
- Psyllidae

Superfamily Aleyrodoidea
- Aleyrodidae

Superfamily Aphidoidea
- Aphididae
- Eriosomatidae
- Adelgidae
- Phylloxeridae

Superfamily Coccoidea
- Margarodidae
- Ortheziidae
- Kerridae
- Coccidae
- Aclerdidae
- Cryptococcidae
- Kermesidae
- Asterolecaniidae
- Lecanodiaspididae
- Cerococcidae
- Dactylopiidae
- Diaspididae
- Conchaspididae
- Phoenicococcidae
- Pseudococcidae
- Eriococcidae

Family Coccinellidae

Subfamily Sticholotidinae
- Microweisini
- Serangiini
- Cephaloscymnini

Subfamily Scymninae
- Zilini
- Stethorini
- Scymnini
- Selvadiini
- Hyperaspini
- Cryptognathini

Subfamily Chilocorinae
- Chilocorini

Subfamily Coccidulinae
- Coccidulini
- Noviini
- Exoplectrini
- Azyini

Subfamily Coccinellinae
- Coccinellini
- Psylloborini

Subfamily Epilachninae
- Epailachnini

Scale Aphids Other

Myzus persicae
Aphidoidea: Aphididae

Coleomegilla maculata

Coccinellinae: Coccinellini

Coleomegilla maculata
(Coleoptera: Coccinellidae)

Coleomegilla maculata

- **Gen: 2-5 per year**
- **Ovi: Eggs in clusters near prey**
- **Prey: Aphids, pollen, eggs**
- **BC: Native, commercially available**

Hippodamia convergens
Coccinellinae: Coccinellini

Hippodamia convergens

- **Gen: 1-2 per year**
- **Ovi: Eggs in clusters 15-20**
- **Prey: Aphids**
- **BC: Native, commercially available**

Coccinella septempunctata

Coccinellinae: Coccinellini

Coccinella septempunctata

- **Gen: 1-2 a year**
- **Ovi: Clusters, up to 50**
- **Prey: Aphids, greenbug**
- **BC: Introduced from Europe, established by accidental introductions, widely distributed**

Harmonia axyridis

Coccinellinae: Coccinellini

Harmonia axyridis

- **Gen: 2-3 a year**
- **Ovi: Clusters ~20**
- **Prey: Aphids, scale insects, psyllids**
- **BC: Introduced from Asia, now widely distributed**

Planococcus citri

Coccoidea: Pseudococcidae

Coccus hesperidum
Coccoidea: Coccidae

Rodolia cardinalis
Coccidulinae: Noviini

Rodolia cardinalis

- **Gen: 8-12 a year**
- **Ovi: Singly under scale covers**
- **Prey: Cottony cushion scale**
- **BC: Introduced from Australia**
  Critical for history of biocontrol

Cryptolaemus montrouzieri
Scymninae: Scymnini

Cryptolaemus montrouzieri

- **Gen: Multiple**
- **Ovi: Singly or small clusters**
- **Prey: Mealybugs**
- **BC: Introduced from Australia, used in citrus and ornamentals**

Rhyzobius lophanthae
Coccidulinae: Coccidulini

Ryzobius lophanthae

- **Gen: Multiple**
- **Ovi: Singly under scale covers**
- **Prey: Red scale, other scale insects**
- **BC: Introduced from Australia**

Chilocorus kuwane

Chilocorinae: Chilocorini

Chilocorus kuwane

- Gen: ~3 per year
- Ovi: eggs singly or small clusters
- Prey: Eunonymus scale and others
- BC: Introduced from Asia
  Commercially available

Delphastus pusillus
Sticholotidinae: Serangiini

Delphastus pusillus

- **Gen: Multiple**
- **Ovi: Singly among prey**
- **Prey: Whiteflies**
- **BC: Used in greenhouses, effective at high prey densities**

Stethorus punctum

Scymninae: Stethorini

Stethorus punctum

- **Gen: 3 per year**
- **Ovi: Singly, under infested leaves**
- **Prey: Mites**
- **BC: Commercially available**

APHIS approved BC agents

Family	n	%
Aphelinidae	17	13.5
Phytoseiidae	15	11.9
Braconidae	14	11.1
Coccinellidae	13	10.3
Pteromalidae	10	7.9
Aphididae	7	5.6
Encyrtidae	6	4.8
Ichneumonidae	2	1.6
Other	42	33.3

Commercially available coccinellids

“Suppliers of Beneficial Organisms in North America”

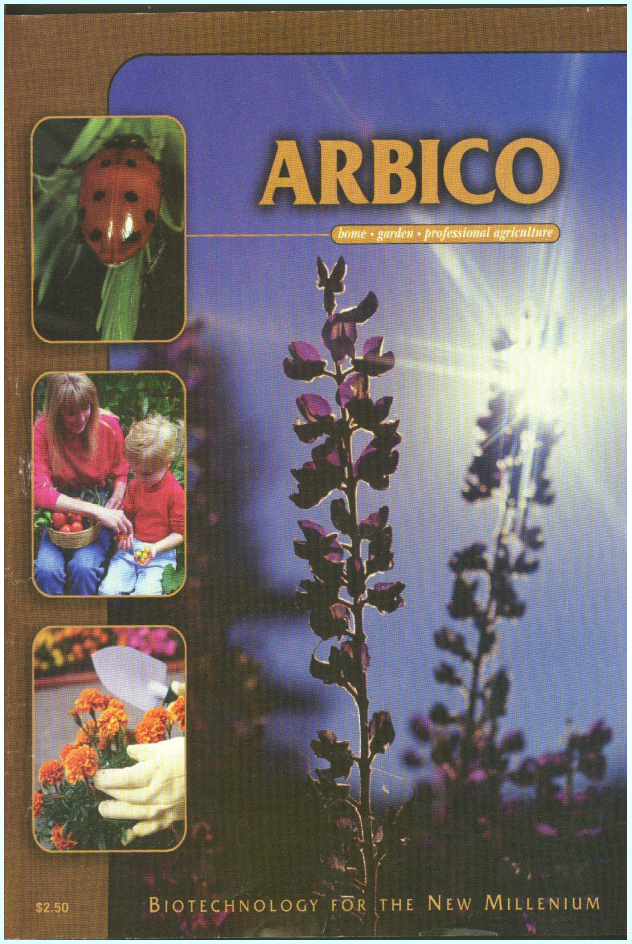
CA EPA

http://www.cdpr.ca.gov/docs/ipminov/bensuppl.htm

Many distributors

Mail order catalogs

Order from the web



Hippodamia convergens
Coccinellinae: Coccinellini

Hippodamia convergens sample prices

Source	quantity	price
The Green Spot	9,000	18.31
Buglogical	9,000	17.50
Biofac Crop Care	9,000	12.00
Arbico	9,000	15.00
The Bug Store	15,000	35.00
Planet Natural	4,500	9.95

Hippodamia convergens

Objections:

- **Not effective; beetle dispersal**
- **A “black eye” on biocontrol**

Case Studies

Aphidophagous (aphid-eating) and Coccidophgagous (scale-eating) lady beetles

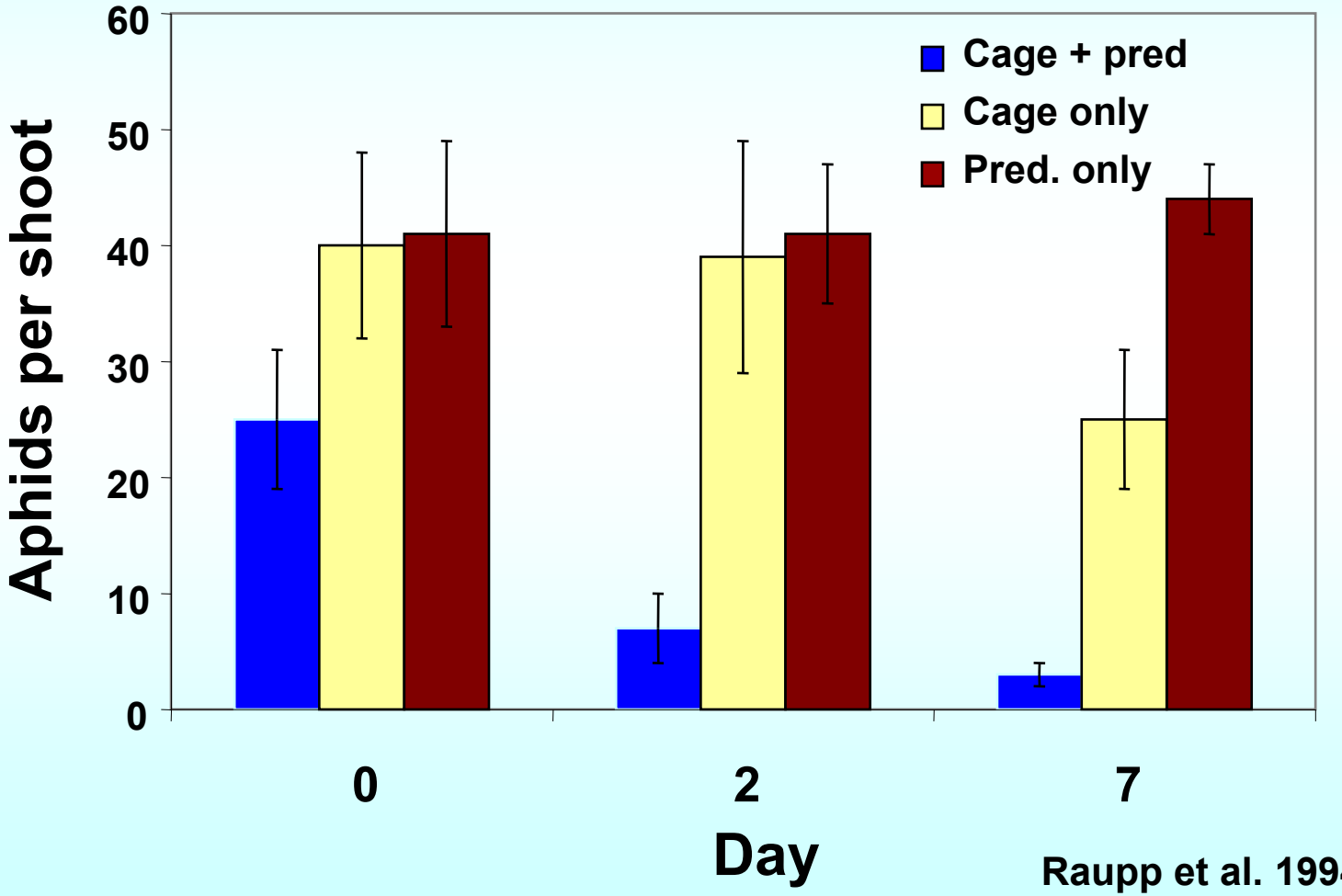
Hippodamia convergens

- **Caged and uncaged firethorn,**
  Pyracantha lelandii

- **Spirea aphid,**
  Aphis spiraecola

Raupp et al. 1994

Aphid numbers on caged and uncaged firethorns following releases of *Hippodamia convergens*



Raupp et al. 1994

Hippodamia convergens

- **Aphids reduced only when beetles confined to plants**
- **Beetle dispersal significant**
- **No prerelease feeding**

Raupp et al. 1994

Hippodamia convergens

- **Potted chrysanthemum,**
  Dendrathema grandiflora

- **Melon aphid,**
  Aphis gossypii

Dreistadt and Flint 1996

Hippodamia convergens

- Aphid numbers reduced on uncaged plants
- Control of 25 - 84% 3 d after release
- Dispersal was significant

Dreistadt and Flint 1996

Chilocorus kuwane

Chilocorinae: Chilocorini

Unaspis euonymi
Coccoidea: Diaspididae

Chilocorus kuwane

- Released *C. kuwane* at 14 sites
- Released *C. kuwane* at a 32-ha apartment complex
- Statewide survey for establishment

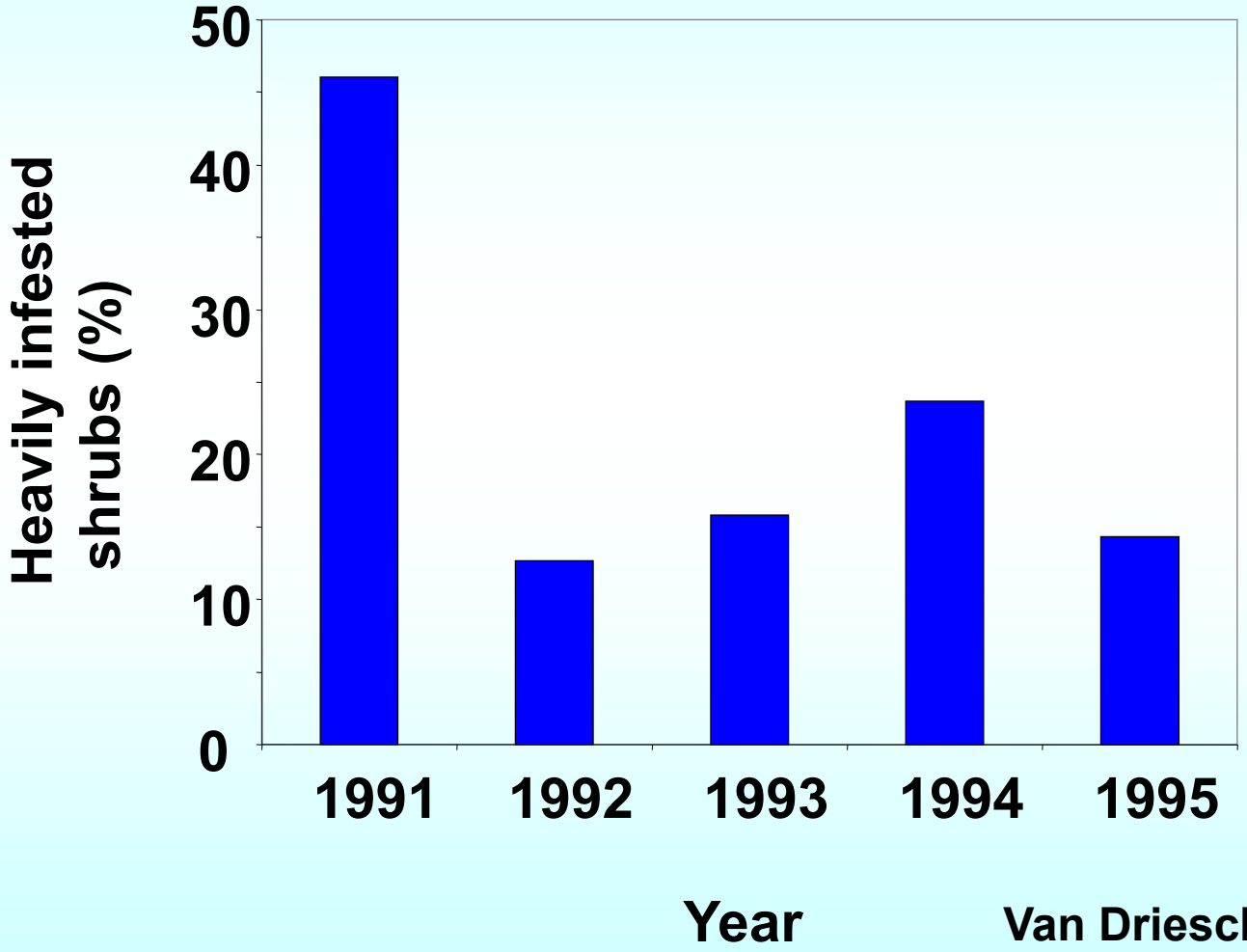
Van Driesche et al. 1998

Chilocorus kuwane

- **Success at 9 of 14 sites**
- **Failure at 3 of 14 sites**
- **Shrubs removed at 2 of 14 sites**

Van Driesche et al. 1998

Shrubs with heavy scale infestations



Van Driesche et al. 1998

Chilocorus kuwane

- **At statewide level, no change**
- **More time required**
- **Overall, project successful**

Van Driesche et al. 1998

Mechanisms of success

Why have coccidophagous beetles succeeded more than aphidophagous lady beetles?

Comparison of life history

- Does development of lady beetles match that of its prey?

- Compared rates of development

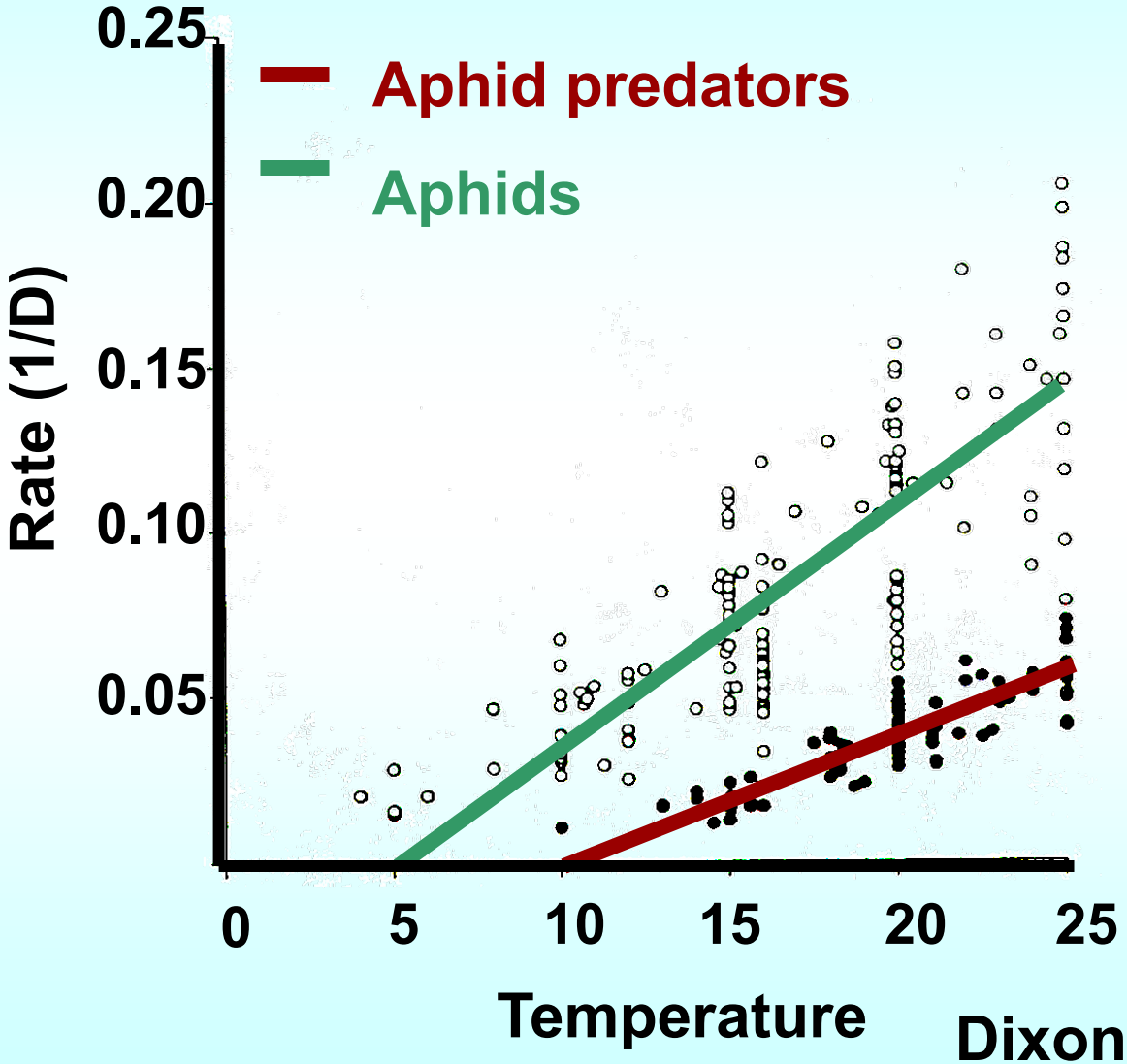
Dixon et al. 1997

Comparison of life history

- Literature survey for development times at a range of temperatures
- 29 aphidophagous species
- 19 coccidophagous species

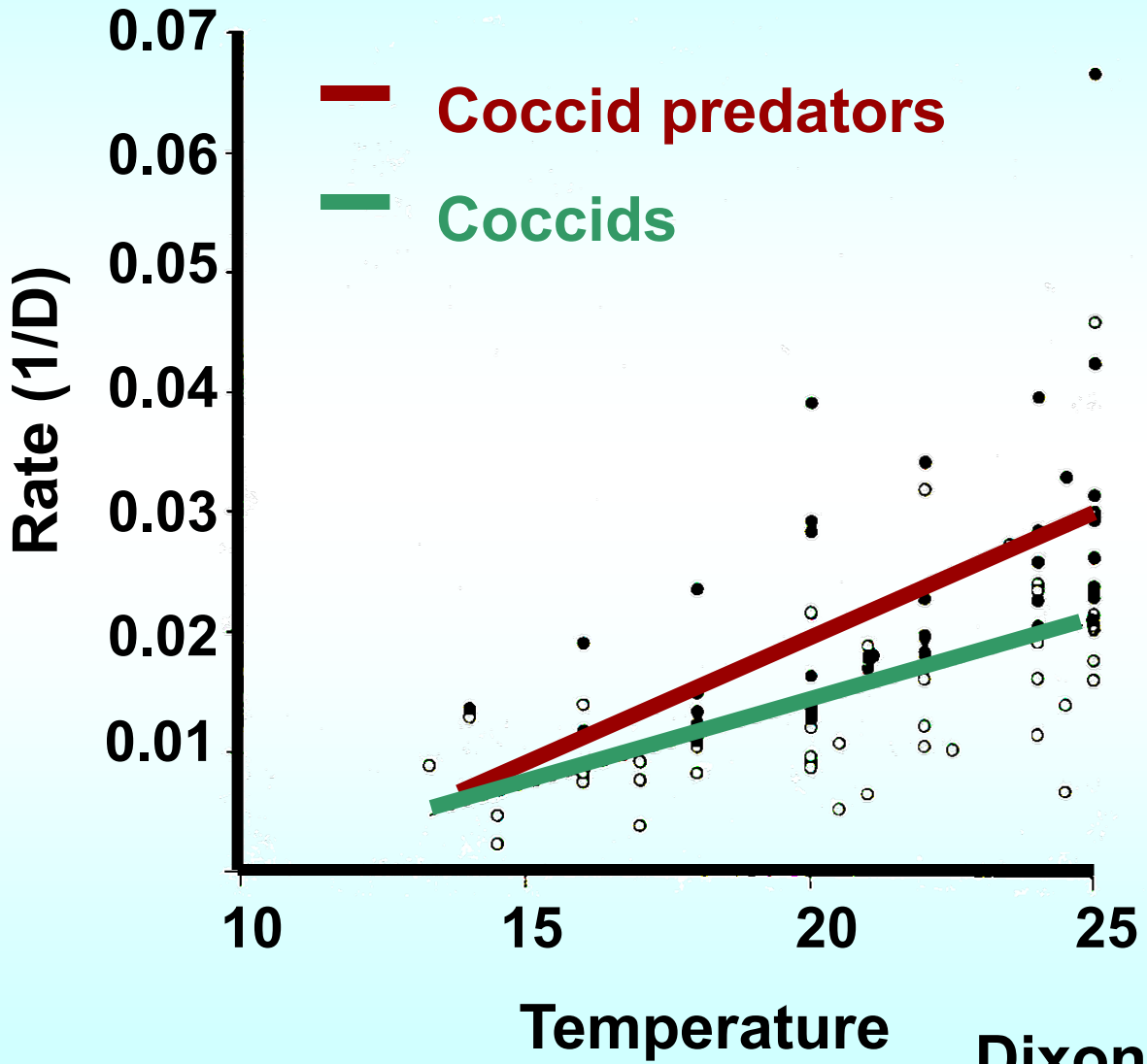
Dixon et al. 1997

Developmental rates of aphids and predators



Dixon et al. 1997

Developmental rates of coccids and predators



Dixon et al. 1997

Comparison of life history

- Aphidophagous lady beetles develop more slowly than aphids
- Coccidophagous lady beetles develop as fast or faster than scales
- Coccidophagous beetles track prey populations

Dixon et al. 1997

Does ovipositional behavior influence success?

Spatial distribution
Cannibalism

Mills 1982

Egg clusters

Eggs laid singly very close to prey

Influence of ovipositional behavior

- An aphidophagous beetle, *Adalia bipunctata*, showed egg cannibalism

- Coccidophagous beetles may avoid high levels of egg cannibalism

Mills 1982

Does prey size and quality influence success?

Number of prey required to develop and produce eggs

Summary: Life history and biocontrol success

- Coccidophagous lady beetles are historically more successful BC agents

- Developmental rate greater

- Oviposition and prey quality

- Oviposition and cannabalism

History of coccinellids in classical biological control

1) **History of coccinellids in classical biological control**
   From the "lady beetle fantasy" period to the present

2) **Current use of coccinellids**
   Habitats and target prey

3) **Mechanisms of success**
   Why certain successes?