Completing an Insecticide Resistance Management Plan for Alfalfa Weevils Damaging Forage Alfalfa in the Western US

Kevin Wanner

MONTANA STATE UNIVERSITY

Ian Grettenberger

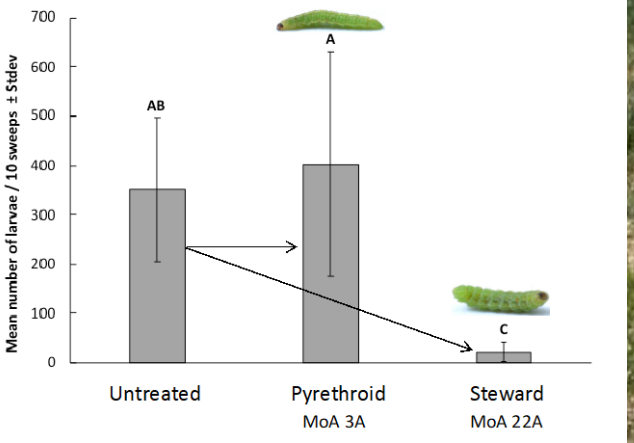
UCDAVIS UNIVERSITY OF CALIFORNIA

NATIONAL ALFALFA & FORAGE ALLIANCE NAFA

USDA

The Problem – Pyrethroid Resistance

- Pyrethroid insecticides are the primary tool used to manage alfalfa weevils
- Reports of control failure after three spray applications
- Only one alternative effective Mode of Action (MoA) insecticide available



Limited Alternatives to Pyrethroid MoA3A

Indoxacarb (Steward) MoA 22A currently the only effective alternative

Insecticides Available for Alfalfa Weevil

MoA	AI	Trade Name	Registrant	PHI
1A	carbaryl	Sevin 4F, Sevin XLR Plus	Tessenderlo Kerley	7d
1A	methomyl	Lannate LV, Lannate SP	DuPont	7d
1B	chlorpyrifos	Cobalt, Cobalt Advanced, Lorsban Advanced, Lorsban 4E, Lorsban 75 WG	Dow AgroSciences, Drexel, Gowan	7-21d
1B	malathion	Malathion 5EC, Malathion ULV Concentrate	Drexel, Loveland Products	0
1B	dimethoate	Dimethoate 2.67, Dimethoate 4EC, Dimethoate 400	Drexel, Loveland, others	10d
1B	phosmet	Imidan 70-W	Gowan	variable
1B/3A	chlorpyrifos + zeta-cypermethrin	Stallion	FMC	7d
3A	alpha-cypermethrin	Fastac EC	BASF	3d
3A	zeta-cypermethrin	Mustang Maxx, Respect EC	FMC, BASF	3d
3A	beta-cyfluthrin	Baythroid XL, Tombstone	Bayer, Loveland	0-21d
3A	gamma-cyhalothrin	Proaxis, Declare	FMC	7d
3A	lambda-cyhalothrin	Warrior II , Silencer, Silencer VXN	Syngenta, ADAMA	7d
3A	permethrin	Ambush 25W, Pounce 25 WP, Arctic 3.2 EC	FMC, AmVac, WinField	0-14d
3A	bifenthrin *	Brigade 2EC, Discipline 2EC	FMC, AMVAC	*
3A/28	lambda-cyhalothrin + chlorantraniliprole	Besiege	Syngenta	7d
22A	**indoxacarb**	**Steward EC**	**FMC**	**7d**
5	spinosad	Entrust SC	Dow AgroSciences	3d

MoA 3A

Removed from market

Pyrethroids, MoA 3A

Several active ingredients (AI) and trade name products

Lose the entire group due to cross-resistance within the same MoA class

Steward remains effective

Approach: Multistate Research & Extension

May

June

February

1

2

3

Advantages:

1. Good field sites
2. Consistent methods
3. Quality data
4. Varied agronomy
5. Collaborators
6. Stakeholders

The Pest: Alfalfa Weevil

Adults active when temperatures above 48°F. Migrate into alfalfa fields to mate and lay eggs

Larvae hatch and feed; first in terminals (left), later on open leaves

Cocoons with pupae form late June and July

Adults migrate to overwintering sites

New adults enter summer dormancy then become active in the fall to feed prior to migrating to overwintering sites

SEP - MAR	APR	MAY	JUN	JUL	AUG

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Research

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Field and Forage Crops

First Report of Alfalfa Weevil (Coleoptera: Curculionidae) Resistance to Lambda-Cyhalothrin in Montana

Erika A. Rodbell[1,] and Kevin W. Wanner

Department of Plant Science and Plant Pathology, Montana State University, 119 Plant BioSciences, Bozeman, MT 59717-3150, USA and [1]Corresponding author, e-mail: erika.rodbell@montana.edu

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Abstract

Forage alfalfa (*Medicago sativa* L. [Fabales: Fabacae]) is a major agronomic crop grown nationally and Montana ranks highly in acres harvested. The alfalfa weevil (*Hypera postica* Gyllenhal [Coleoptera: Curculionidae]) is the primary defoliating pest that requires insecticide applications to prevent yield loss, particularly pyrethroid active ingredients (a.i.) that are both efficacious and cost-effective. Reports from commercial alfalfa producers in Big Horn County, MT, suggested local populations of alfalfa weevil had developed resistance to the pyrethroid a.i. lambda-cyhalothrin (type II pyrethroid). Chemical control is an important component of integrated pest management (IPM) of alfalfa weevil and the loss of pyrethroid a.i. as an effective tool would result in additional production costs. Two locations in southern Big Horn County and nine locations in four other Montana counties where resistance has not been reported were sampled and assayed for resistance to lambda-cyhalothrin. Populations from three counties were susceptible, the concentration causing 50% mortality (LC_{50}) ranged from 0.02 to 0.10 μg/cm^2. In contrast, populations from Big Horn County did not reach 50% mortality at the highest concentration of lambda-cyhalothrin tested (3.30 μg/cm^2), indicating high levels of resistance have developed in these populations. A field trial in Big Horn County supported laboratory results of resistance; lambda-cyhalothrin at the highest label rate did not reduce alfalfa weevil populations. Additional bioassays suggest cross-resistance to zeta-cypermethrin (type II pyrethroid), but only partial cross-resistance to permethrin (type I pyrethroid).

Objective: Determine the Extent and Severity of Pyrethroid Resistance in the Western US

- LC_{50} values for >80 sites
- Group into three categories: Susceptible, moderate resistance & high resistance
- 100 fold range in LC_{50} values

Resistance Category	LC50 (µg/cm²)	Times (X) Higher Label Rate (0.34 µg/cm²)
Susceptible	<0.3	< 0.9X
Moderate	0.30 -0.99	0.9X - 2.9X
High	> 1.00	> 2.9X

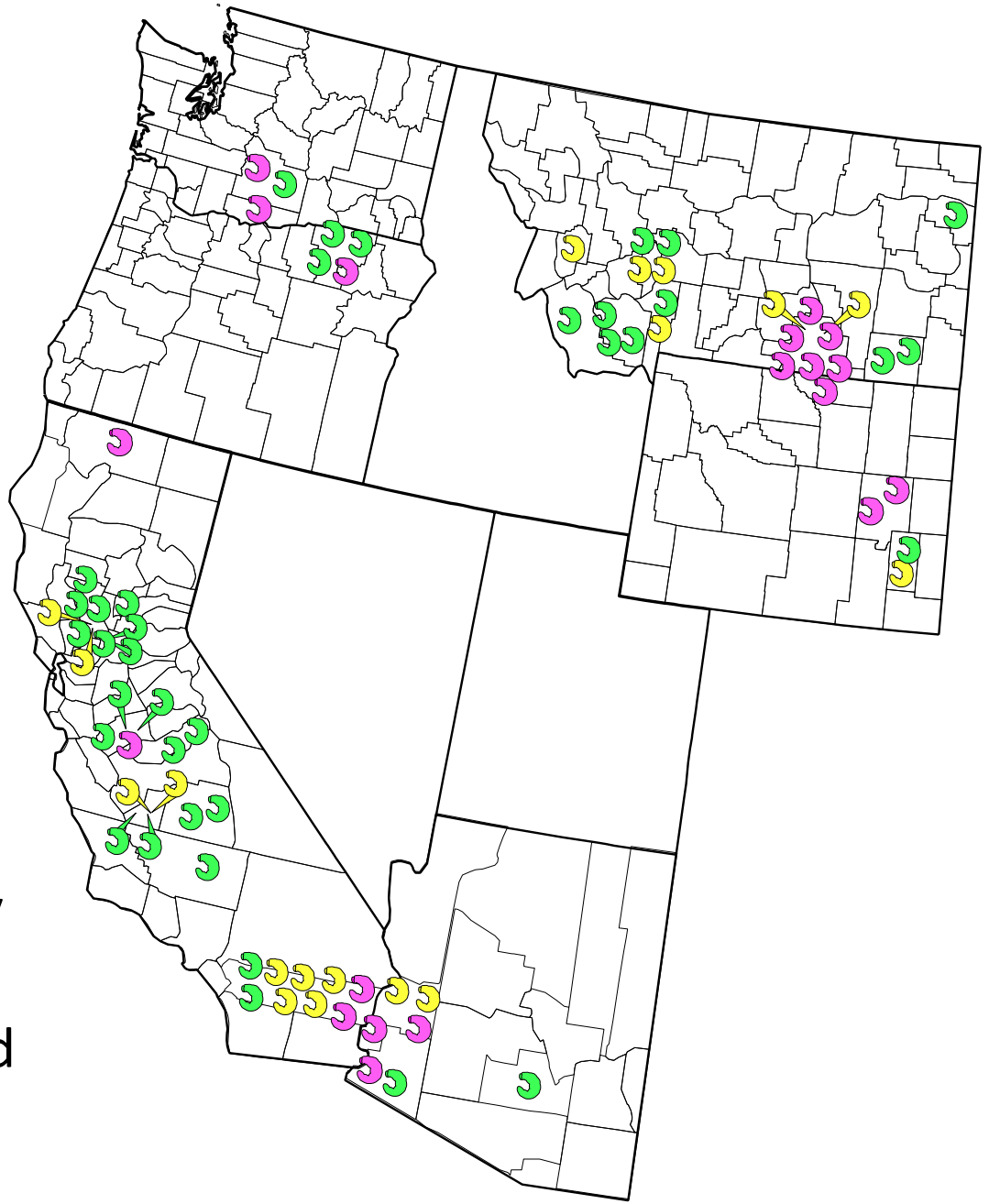
State	County	Field Site #	LC_{50} µg/cm²
Arizona	Yuma	1	0.18
		2	0.12
		3	1.35
	La Paz	1	1.55
		2	0.65
		3	6.5
		4	2.78
		5	0.91
	Pinal	1	0.13
California	Riverside	1	0.29
		2	0.22
		3	0.53
		4	0.27
			0.92
Kansas	Lyon	1	6.65
Montana	Beaverhead	1	0.43
	Gallatin	1	0.05
		2	0.16
	Ravali	1	0.37
		2	0.19
	Big Horn	1	>3.3
		2	>1.0
		3	>3.3
Washington	Klickitat	1	0.13
Wyoming	Park	1	0.42
	Sheridan	1	12.07

Resistance to Lambda Cyhalothrin (Warrior & Generics)

Resistance Category	LC_{50} ($\mu g/cm^2$)	Resistance Ratio ($LC_{50}/0.01$)
Susceptible	<0.30	<30x
Moderate	0.30 – 1.0	30x – 100x
High	> 1.0	>100x

Conclusion

- Every western state investigated has a highly resistant population of alfalfa weevil
- Every state has susceptible populations; an opportunity to mitigate resistance and extend the use of pyrethroid active ingredients



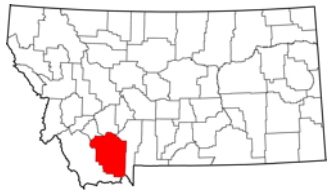
Objective: Are Alfalfa Weevils Resistant to all Pyrethroid A.I. (Cross-Resistance) ?

3A	alpha-cypermethrin
3A	zeta-cypermethrin
3A	beta-cyfluthrin
3A	gamma-cyhalothrin
3A	lambda-cyhalothrin
3A	permethrin
3A	bifenthrin *

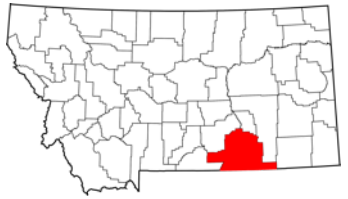
Compare the effectiveness of the different active ingredients against alfalfa weevils **resistant** to lambda cyhalothrin (Warrior)

Laboratory bioassay: Compare resistant and susceptible populations in three regions, 6 A.I

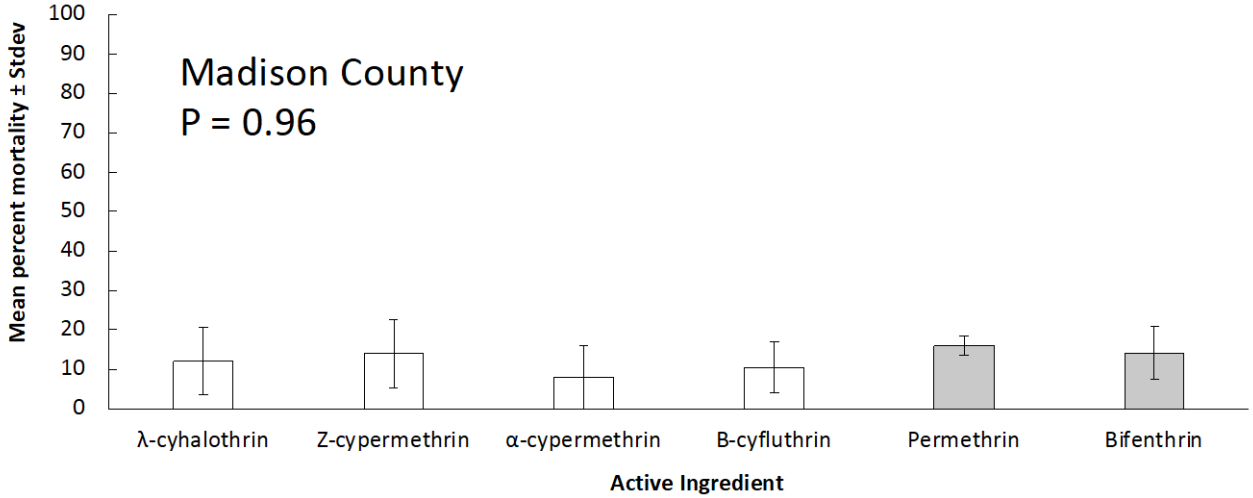
Field trials: Test the commercial products against **resistant** alfalfa weevils in three regions

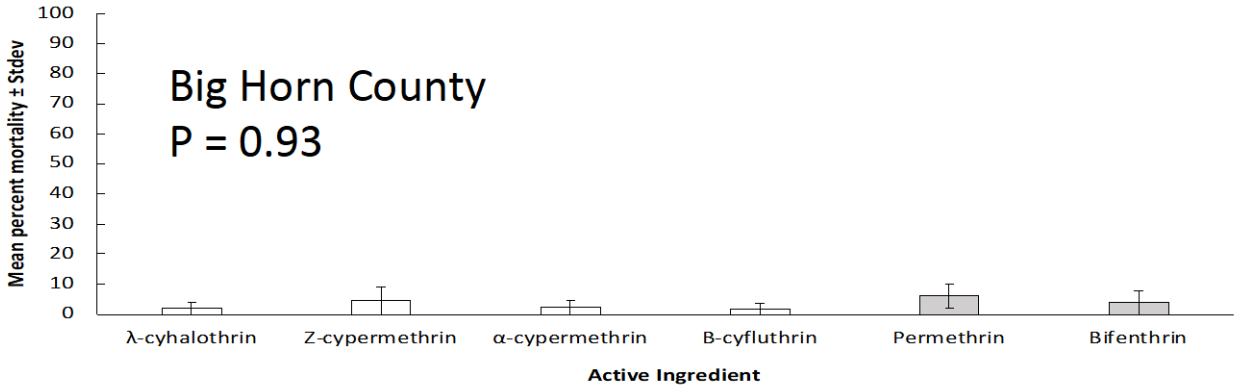


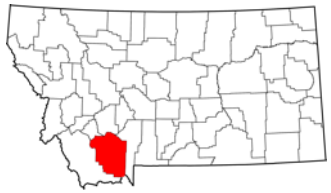
Laboratory Assay: Madison (S) vs Big Horn County (R)



- Discriminating Doses (blank vials vs high dose)
- Control Mortality Low (blank vials)







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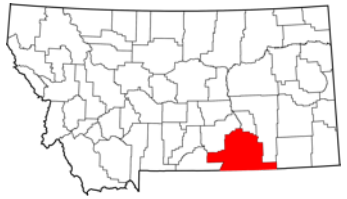
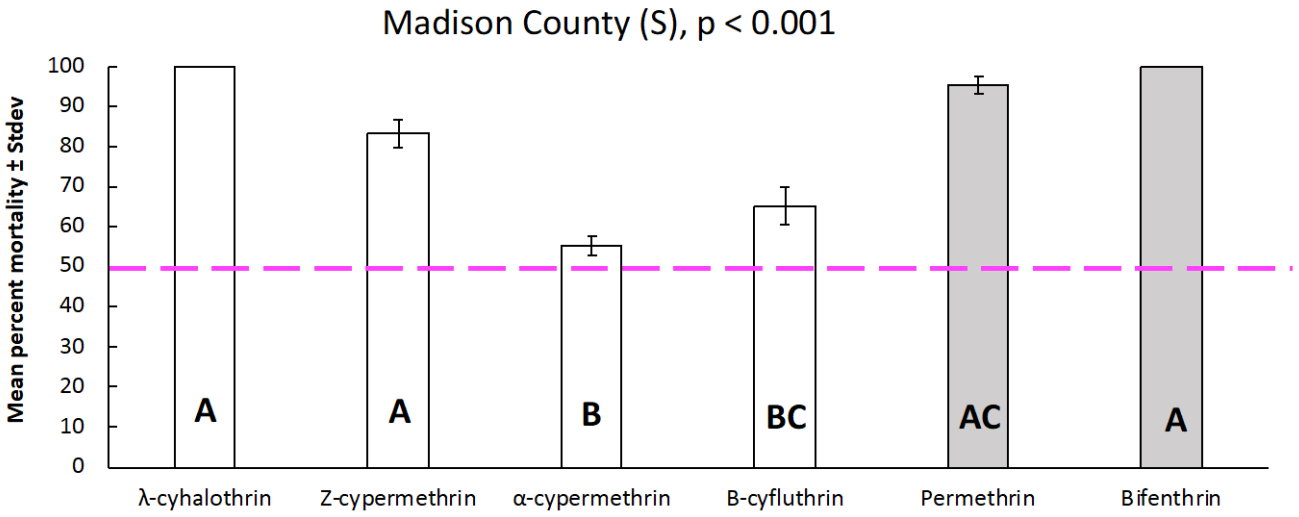
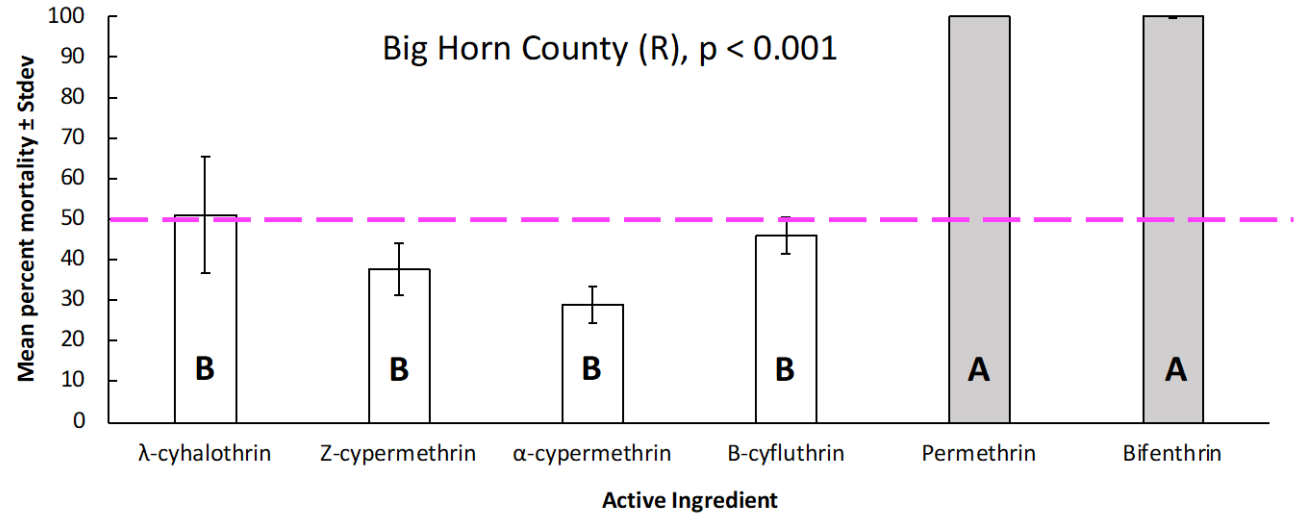


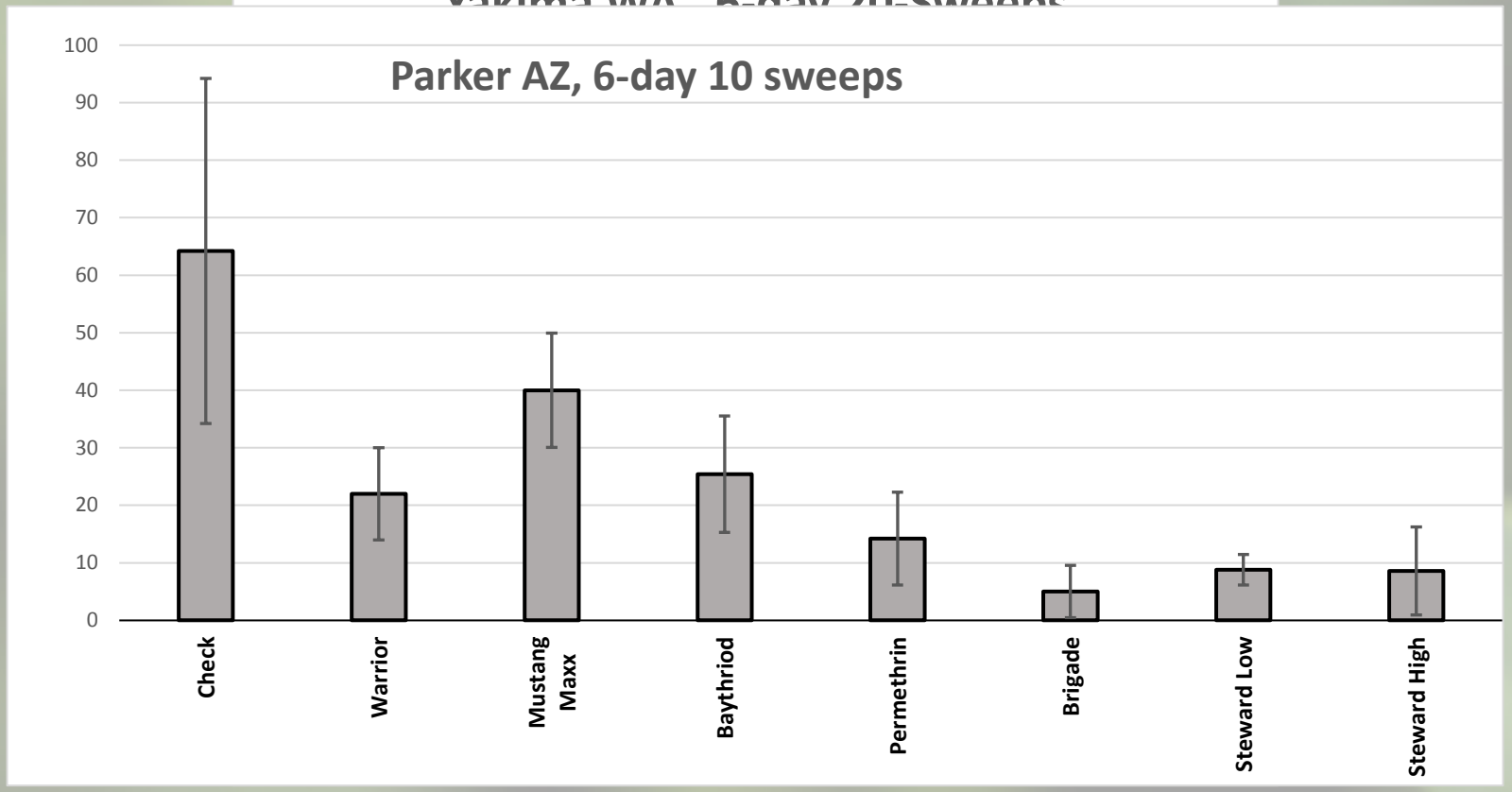
- **High Discriminating Dose**





Field Trial Results, Resistant Populations
Yakima WA & Parker AZ

- Field and lab results similar
- Pyrethroid AI generally ineffective on resistant populations with the exception of bifenthrin (Brigade)



Summary

- Resistance is widespread; Cross-resistance
- Bifenthrin for seed alfalfa
- Pattern consistent across the West
- Manage for Resistance (IPM, Rotate MoA)
- **Have to preserve** Steward
- Regional Extension – Consistent Message
- Collaboration with all stakeholders
- Continuing and future research

Resistant Alfalfa Weevil Project

Welcome to RAW Sign Up Our Collaborators

www.montana.edu/resistantalfalfaweevil/

Funded by USDA NIFA Alfalfa Seed and Alfalfa Forage Systems Program

The Resistant Alfalfa Weevil Project (RAW) is a multistate collaboration working to:

- Quantify the level of resistance to pyrethroid insecticides in locations where it has established
- Map the geographic spread of resistant alfalfa weevil populations
- Identify risk factors for the development of pyrethroid-resistant alfalfa weevils
- Develop resistance management recommendations for Western Region alfalfa producers and stakeholders to mitigate the economic impacts of insecticide resistance.

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