Biological control of *Arundo donax*; an invasive weed of the Rio Grande Basin

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Research Team

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- **Beto Perez de Leon, Felix Guerrero,** USDA-ARS, Kerrville, TX, ant impacts, decomposition of dead biomass
- **Patrick Moran**, USDA-ARS, Albany, CA evaluation of agents in CA.
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- **Massimo Cristofaro**, BBCA, Foreign exploration in Italy
- **John Gaskin**, USDA-ARS, Sidney, MT Genetic characterization of biological control agents
- **Matt Ciomperlik, Aaron Carlson**, USDA-APHIS, Edinburg, TX, Aerial release of agents, implementation program
- **Maricela Martinez Jimenez** – Instituto Mexicano de Tecnologia del Aguas, Cuernavaca, Mexico, Evaluation of biological control agents in Mexico
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- **Eduardo Galante, Maria Angeles Marcos, Elena Cortez Mendoza** – Univeresidad de Alicante, Spain, Biology of the arundo scale in Spain
- **Mike Grusak,** USDA-ARS, Houston, TX plant nutrient effects on agents
- **Ron Lacewell,** – Texas A&M Agrilife, College Station, Economic impact of *Arundo donax* in the Rio Grande Basin
- **Jim Manhart, Alan Pepper, Daniel Tarin** - Texas A&M, College Station, Molecular genetics of Arundo and biological control agents
- **Chenghai Yang** - USDA-ARS, College Station, TX, Remote sensing

Research Funding

- Dept. of Homeland Security, Customs and Border Protection
- U.S. Dept. of Agriculture

Arundo donax L.

- ► Common names: giant reed, carrizo cane
- ► An invasive weed in riparian habitats
- ► Declared noxious weed – 45 States, listed by Cal EPPC, SE EPPC
- ► In Mexico declared noxious weed (CONABIO)
- ► Also invasive in Argentina, Australia & South Africa

Presentation

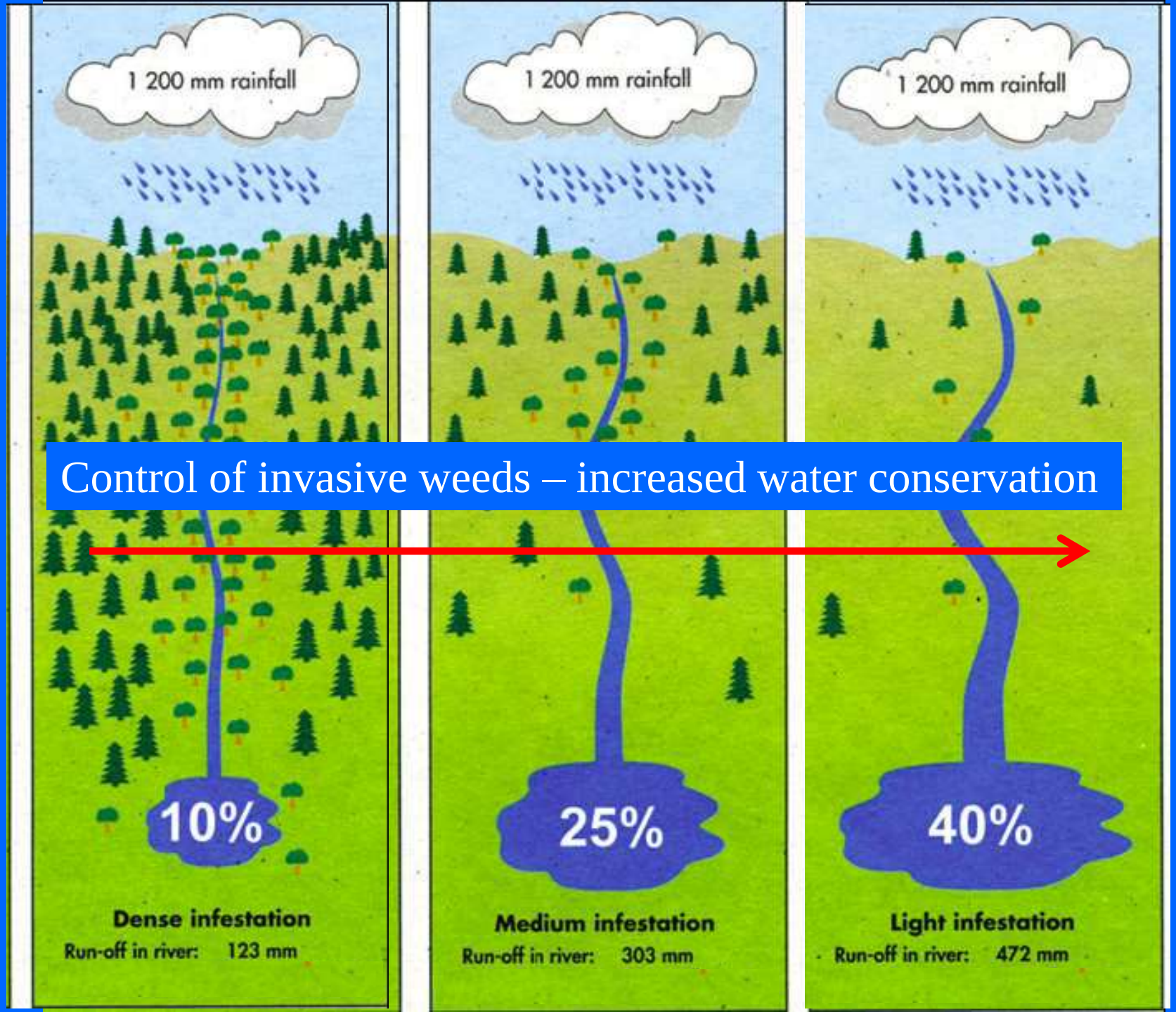
- Impacts of Arundo in Rio Grande Basin
- Comparison to native range in Europe
- Biological control program in TX & Mexico
- Immediate Results: **New** Mechanical Topping + Biological Program to achieve immediate visibility of river
- Summary of accomplishments

Impacts of Arundo in the RGB

- Water Availability
- Environmental
- National Security
- Livestock Health

How do we conserve water in Rio Grande Basin

- Reduce urban landscape water use
- Industrial water recycling
- Reduce irrigation losses – line canals
- **Control invasive water-using weeds**



Control of invasive weeds – increased water conservation

Impacts of *Arundo donax*

- Water Availability
- Environmental
- National Security
- Animal Health

Environmental
Rio Nadadores, Coahuila, México
Extinction of endemic fish species

U.S. National Security

Livestock Health

River willows

Infested cattle

Cattle fever tick

1. Arundo enhances survival of tick
2. Transition back to native vegetation--better biological barrier to ticks

Racelis, A.E., R. B. Davey, J. A. Goolsby, A. A. Pérez de León, K. Varner, and R. Duhaime. 2012. Facilitative ecological interactions between invasive species: Arundo donax (Poaceae) stands as favorable habitat for cattle ticks (Acari: Ixodidae) along the US-Mexico border. Journal of Medical Entomology 49: 410-417.

Infested deer

Invasive
Monoculture
South of Del Rio

Invasive
Monoculture
Laredo, Texas

Invasive
Monoculture
Irrigation canal, Weslaco

Comparison of *Arundo donax* in its native range in Mediterranean Europe

Native Biodiverse Ecosystem
Mediterranean coast of Spain near Malaga

Native Biodiver
Ecosystem
Ebro River, Tortosa, Spain

Native Biodiverse Ecosystem
Rivesaltes, France

Biological Control of *Arundo donax*

- Long-term, sustainable
- Low cost
- Environmentally friendly
- Bi-national agreement

Biological Control Agents

Arundo wasp

Arundo scale

Biocontrol agents transferred to Mexico
U.S.-Mexico binational program

Testing of Biocontrol Agents

Host Range Testing of Agents (Environmental Safety)

- 42 plant species tested.
- All closely related grasses and economic crop grasses tested
- Habitat associates (willows, palms, etc.) tested
- Insects placed on plants under ideal conditions
- Insect behavior observed for > 10 hours
- Plants held to determine if any reproduction of biological control agent
- Results reviewed by Technical Advisory Group (TAG) in Canada, U.S. and Mexico.

Biological Control Agents

Arundo wasp

Tetramesa romana
Arundo wasp
Hymenoptera: Eurytomidae
larvae feed on stems & side shoots (adult stingless)

Released April 29, 2009

Arundo scale

Rhizaspidiotus donacis
Arundo scale
Homoptera: Diaspididae
scale insects feed on roots and side shoots

Released Dec 17, 2010

Arundo leafminer

Lasioptera donacis
Arundo leafminer
Diptera: Ceccidomyidae
Larvae are leaf sheath miners causing defoliation

Released Dec. 2016

Arundo fly

Cryptonevra spp.
Arundo fly
Diptera: Chloropidae
fly larvae feed on new stem shoots

Testing in Europe

Tetramesa romana (Hymenoptera: Eurytomidae)

- Adult females live 4-5 days and reproduce via parthenogenesis-
- One female produces an avg. of 26 new adults; max of 66.
- Larvae develop inside cane (endophagy) in 30-35 days.
- Almost all (90%) of egg-laying and feeding occur at shoot tip.
- Growth of plant stunted by gall.
- Host specific to *Arundo donax*.

Goolsby J. A. and Moran, P. J. Host range of *Tetramesa romana* Walker (Hymenoptera: Eurytomidae), a potential biological control of giant reed, *Arundo donax* L. in North America. Biological Control 49:160-168. 2009.

Moran, P. J., and Goolsby, J. A. Biology of the galling wasp *Tetramesa romana*, a biological control agent of giant reed. Biological Control 49:169-179. 2009.

Wasp Impacts on Growth

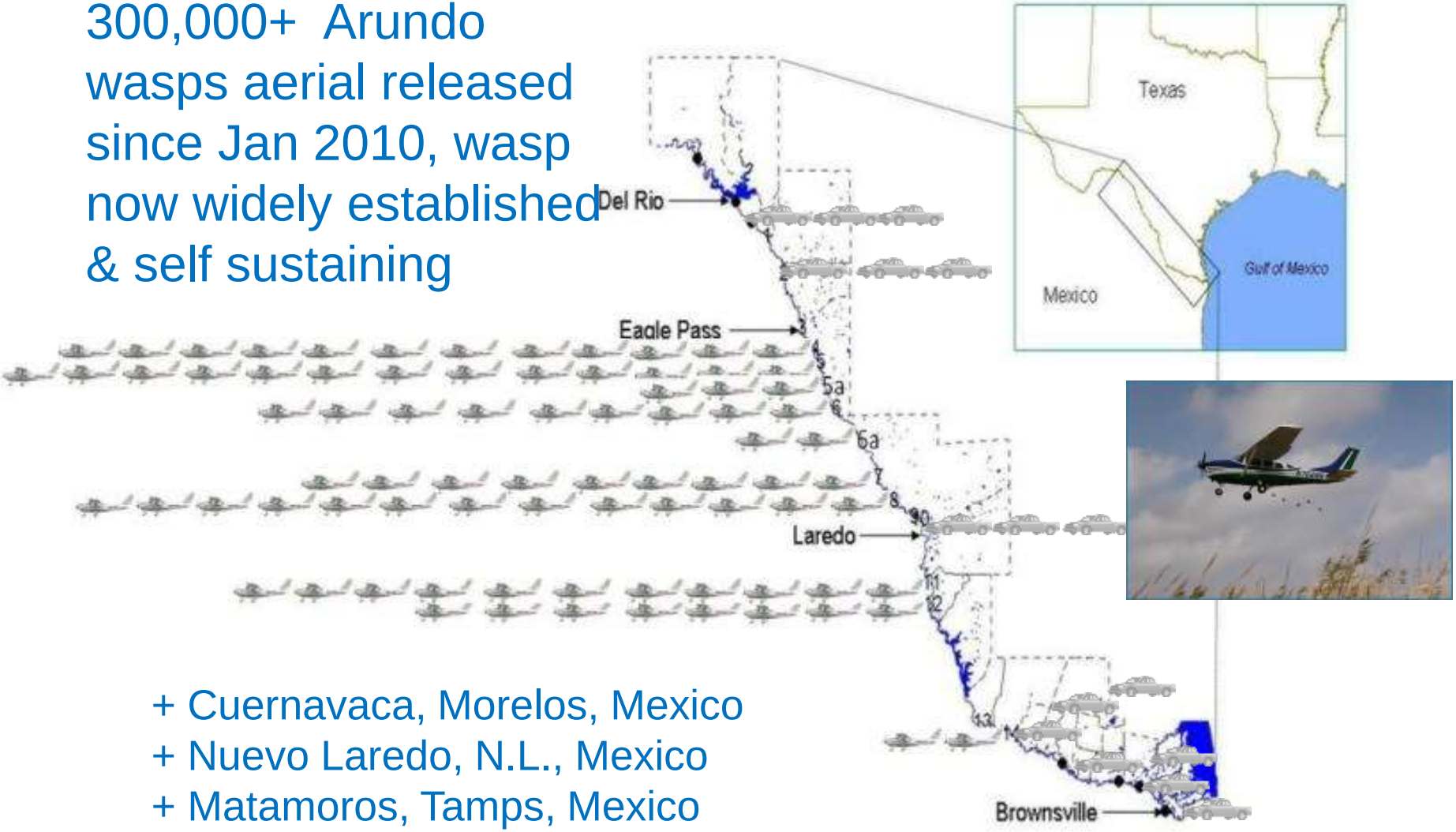
Side shoot galls, ideal for arundo scale

Arundo wasp damage LRGV

Aerial release of arundo wasps

Racelis, A.E., Goolsby, J.A., Penk, R., Jones, W.K., and Roland, T.J. 2010. The inundative, aerial release technique for the arundo wasp, a biological control age *Arundo donax*. Southwestern Entomologist. 35: 495-501.

300,000+ Arundo wasps aerial released since Jan 2010, wasp now widely established & self sustaining



+ Cuernavaca, Morelos, Mexico
+ Nuevo Laredo, N.L., Mexico
+ Matamoros, Tamps, Mexico

Table 1. Comparison of *Tetramesa romana* densities using two-minute exit hole counts from its native and introduced ranges

Region	GPS Coordinates	N	Mean ± Standard Error*
Alicante, Spain	38°20’45”N, 0°29’26” W	10	2.2 ± 0.6[a]
Montpellier, France	43°36’38”N, 3°52’36”E	10	3.6 ± 1.2[a]
Rome, Italy	41°54’10”N, 12°29’46”E	17	5.8 ± 1.0[a]
Crete, Greece	35°30’49”N, 24°01’04”E	16	6.8 ± 1.6[a]
Thessaloniki, Greece	40°38’24”N, 22°56’39”E	25	4.4 ± 1.6[a]
Oxnard-Ventura, California, USA	34°11’51”N, 119°10’37”W	19	7.0 ± 1.6[a]
Pietermaritzburg, South Africa	29°36’02”S, 30°22’46”E	11	44.8 ± 10.9[b]
Texas (Rio Grande), USA**	25°54’06”N, 97°29’50”W	50	115.4 ± 8.1[c]

* Means with different letters are significantly different ($P < 0.05$)

**Data is a composite of all counts on Rio Grande between Brownsville and Del Rio, TX.

Table 5. Annual precipitation, mean temperatures and heat units for all *Tetramesa romana* locations in 2017.

Region	Annual Precipitation Totals (cm)	Annual Mean Temperature °C	Mean Winter Temperature* °C	Heat Units °C
Brownsville, Texas, USA	58.1	24.9	19.1	5513
Laredo, Texas, USA	59.9	24.9	17.6	5391
Del Rio, Texas, USA	61.0	22.2	13.9	4429
Alicante, Spain	23.3	19.0	12.8	3316
Crete, Greece	45.4	18.3	11.1	3123
Pietermaritzburg, South Africa	61.7	15.6	11.7	3010
Oxnard-Ventura, California, USA	18.1	17.0	14.3	2571
Rome, Italy	33.5	16.2	8.2	2294
Thessaloniki, Greece	32.9	15.9	6.7	2117
Montpellier, France	34.0	15.6	7.6	2047

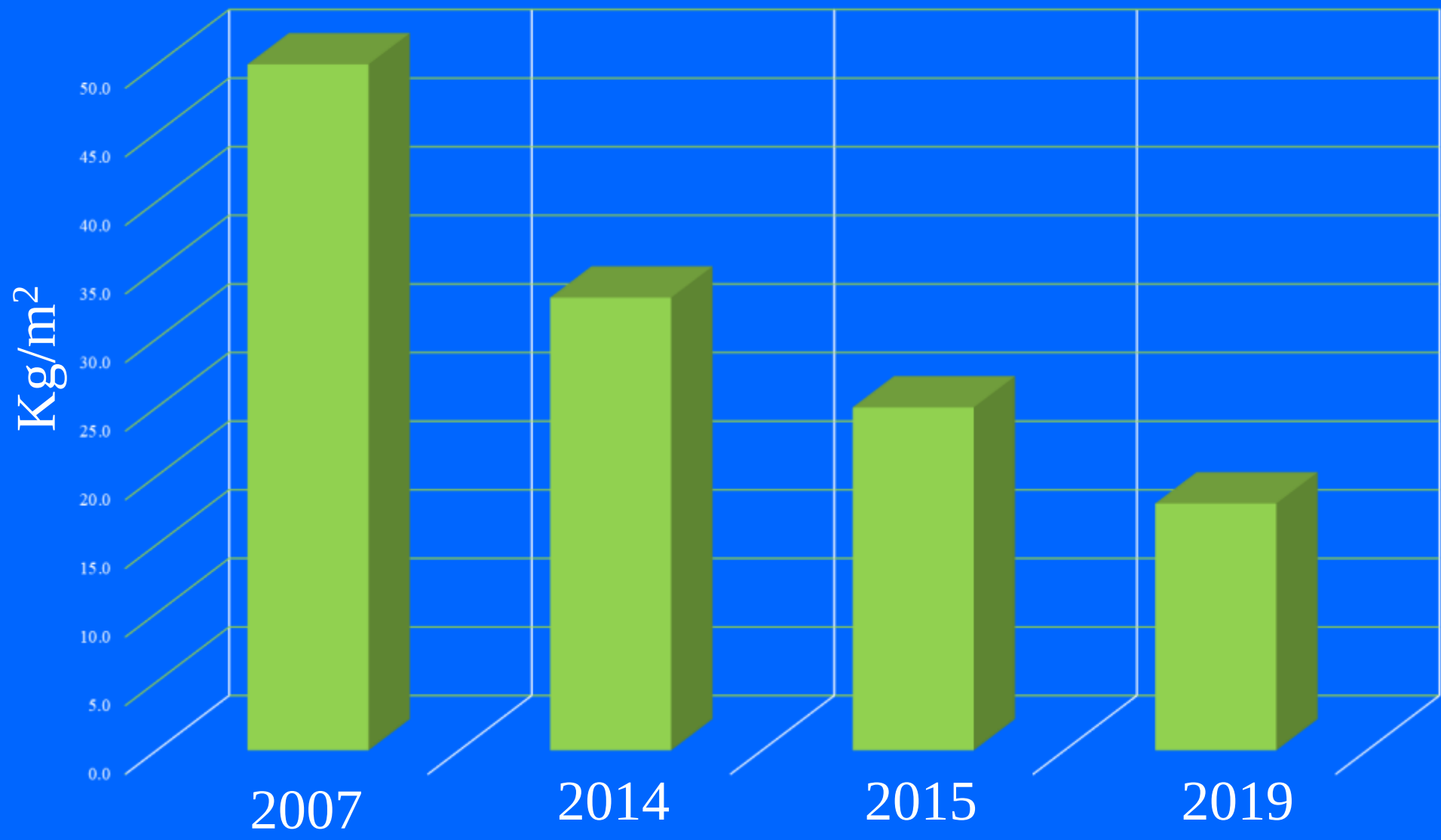
Rhizaspidiotus donacis, Arundo scale

- Feeds on roots and stems, host specific to *Arundo*
- Adult female survival (on plant until reproductive maturity): 203 days
- Average crawler production by individual female: 85 to 300, 50-80% of females are reproductive
- Highly significant impact on *A. donax*

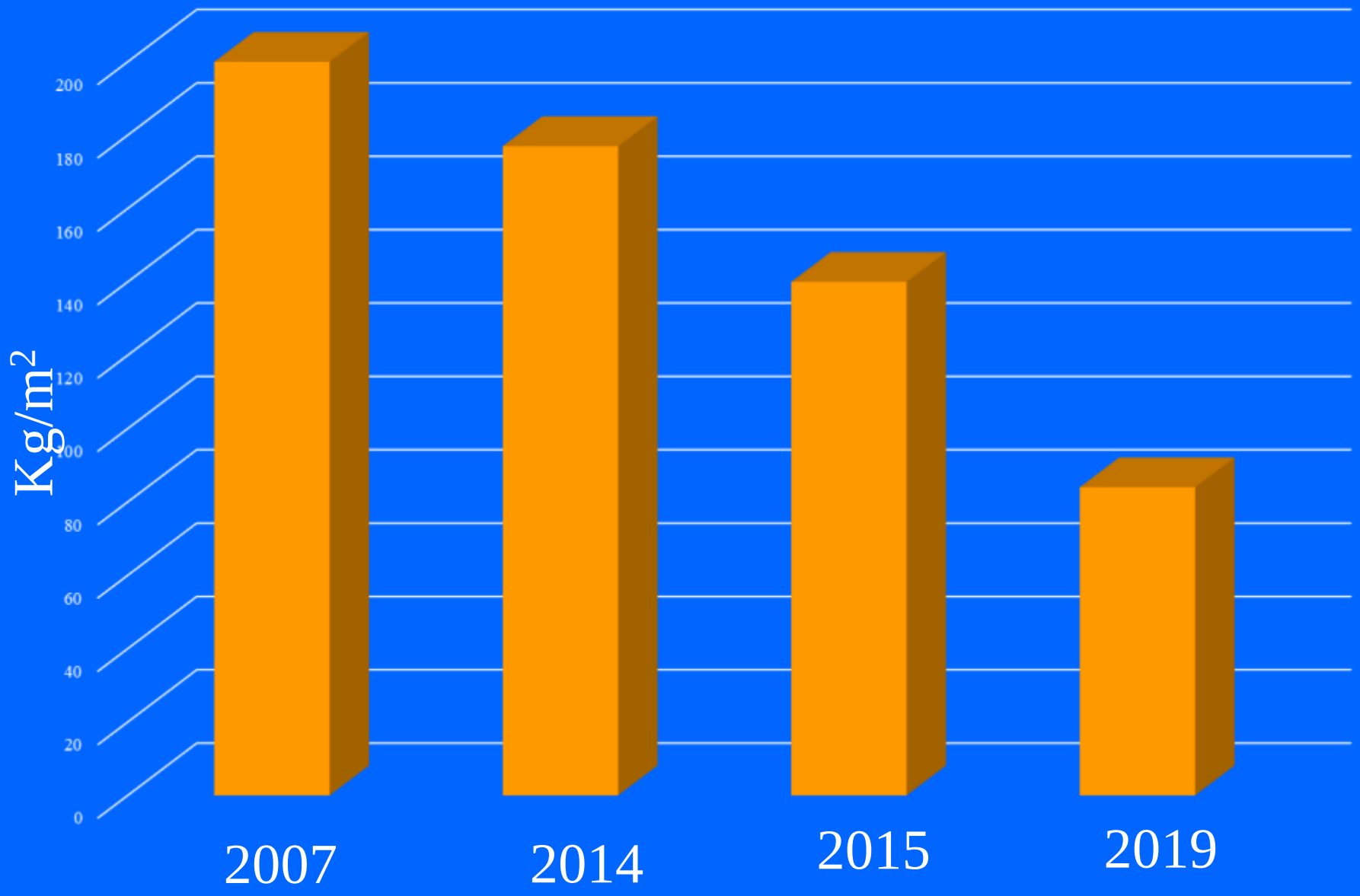
- Goolsby, J. A., Moran, P. J., Adamczyk, J. A., Kirk, A. A., Jones, W. A., Marcos, M. A. and *Cortés, E.* 2009. Host range of the European, rhizome-stem feeding scale *Rhizaspidiotus donacis* (Leonardi) (Hemiptera: Diaspididae), a candidate biological control agent for giant reed, *Arundo donax* L. (Poales: Poaceae) in North America. 19: 899-918
- Moran, P. J., and Goolsby, J. A. 2010. Biology of the armored scale *Rhizaspidiotus donacis* (Hemiptera: Diaspididae), a candidate agent for biological control of giant reed. Annals of the Entomological Society of America 103: 252-263

Arundo scale damage

Decline in *Arundo donax* 2007 to 2019
Los Indios, TX



Decline in *Arundo donax* 2007-2019
Laredo, TX



Region-wide impact of biological control program

- 22 % reduction in *A. donax* biomass between Del Rio and Brownsville (2014)
- 2.5 million tons of *A. donax* removed
- 6000 acre ft of irrigation water conserved per year
- Visibility into stands increased from 6 to 27 ft.
- Ecological transition back to native vegetation beginning

John A. Goolsby, Patrick J. Moran. Alexis E. Racelis, Kenneth R. Summy, Maricela Martinez Jimenez, Ronald D. Lacewell, Adalberto Perez de Leon, & Alan A. Kirk. 2015. Impact of the biological control agent, *Tetramesa romana* (Hymenoptera: Eurytomidae) on *Arundo donax* (Poaceae: Arundinoideae) along the Rio Grande River in Texas. Biocontrol Science & Technology

Presentation

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- Immediate Results: **New** Mechanical Topping + Biological Program to achieve immediate visibility of river
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Control of Carrizo Cane
Topping + Biological Control Insects

Topping tractor with 42 reach over bank of Rio Grande

Tractor with cutter bar for topping cane to 3-4 feet

Cane topper

Carrizo Cane

6 months after topping at 3 ft

6 months after mowing cane to ground

Before and after topping + plus biocontrol insects. Clear view of Rio Grande near Laredo

Arundo wasp feeds above ground on canes

Arundo scale feeds below ground on roots

Scale-killed new shoot

Damage to cane from biocontrol insects

Advantages:

- Topping provides immediate visibility of river for law enforcement.
- After topping biocontrol insects suppress regrowth of carrizo cane for 1 year.
- No environmental issues.
- Biocontrol process is gradual, which keeps river bank stable and prevents erosion.
- Ready acceptance by landowners
- Mexico supports biocontrol program and is also releasing insects.
- The native trees, shrubs, and grasses re-grow to fill the void, which leads to significant water conservation.
- Biocontrol is permanent, no need for re-release of insects.
- All Federal permits (NEPA) in place for immediate action.

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Edinburg, TX (Moore Airbase)

Immediate visibility and long-term control

Mechanization of Topping

Topping Tractors

La Azteca Island, Laredo, TX

La Azteca, Laredo, TX

Before

After

Visibility on Day 1 and stays for 1 year, no standing dead cane, no fire hazard

300 Yard Visibility

USDA employee at far end

How long does topping + bio keep carrizo cane stunted?

11 months after topping – Brownsville, TX

Conclusions

- *Arundo donax* is extremely invasive with multiple social, political, agricultural and environmental impacts in the riparian habitats of the Southwestern U.S. watersheds.
- Significant economic benefits from control of *A. donax*
- Biological control best adapted strategy for long-term basin-wide control
- Biological control program has released 3 agents from Spain, gall-forming wasp, armored scale, & leafminer
- Significant benefits to Rio Grande Basin.
- >6000 acre feet of water conserved per year
- Texas Agrilife model – $5 million in benefits per year

Summary

- *Arundo donax*, carrizo cane is declining along Rio Grande from Del Rio to Brownsville due to attack by biocontrol insects
- New topping techniques synergizes with biocontrol to provide immediate visibility and is a <u>scalable</u> technology for Rio Grande

Investigation of the impacts of *Arundo donax* and Evaluation of Candidate Biological Control Agents in México

Dra. Maricela Martínez Jiménez
Research Entomologist
Jiutepec, Morelos, México

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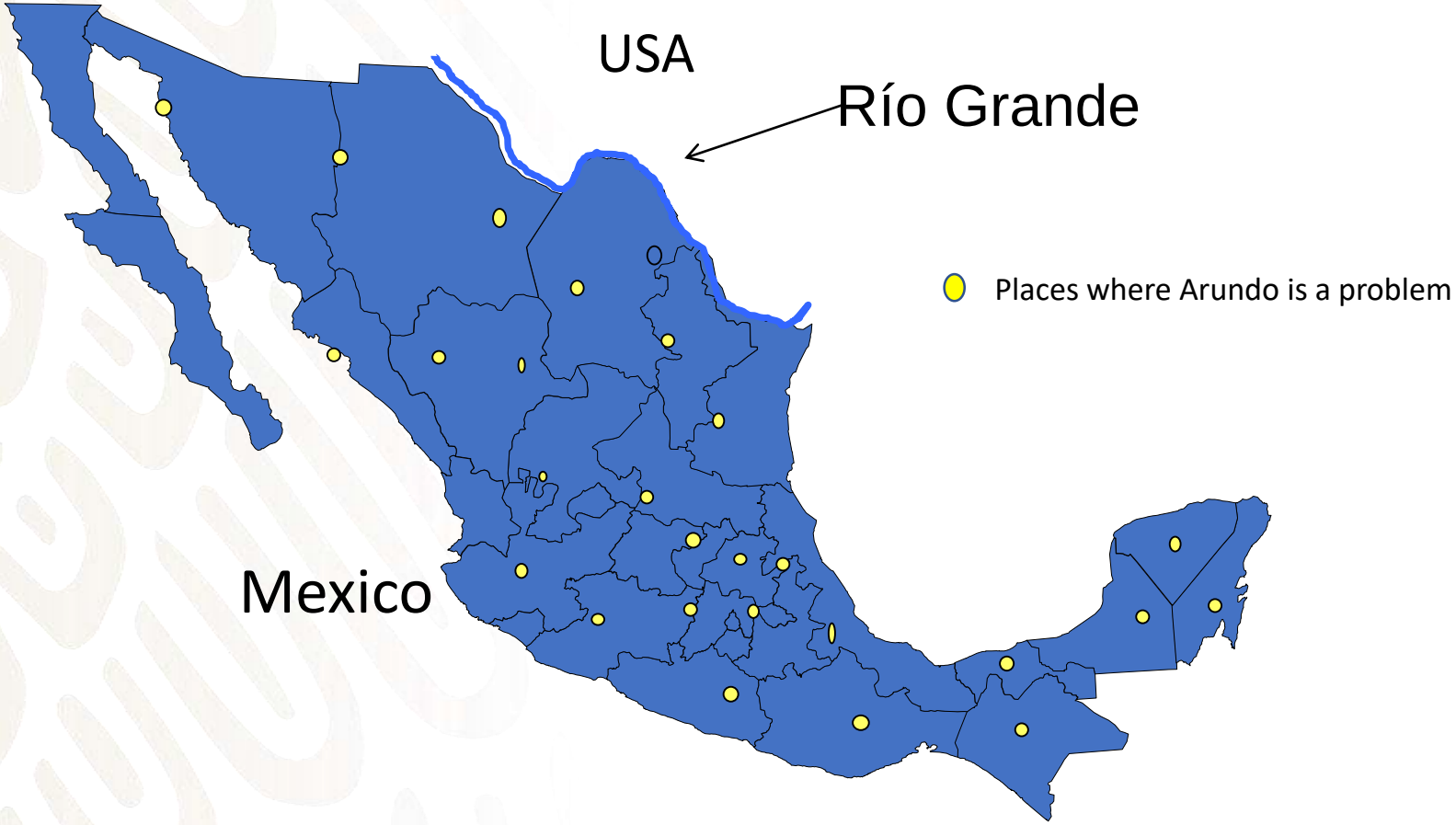
Arundo was introduced to México from Spain



Arundo in Rio Grande (Nuevo Laredo, Texas)

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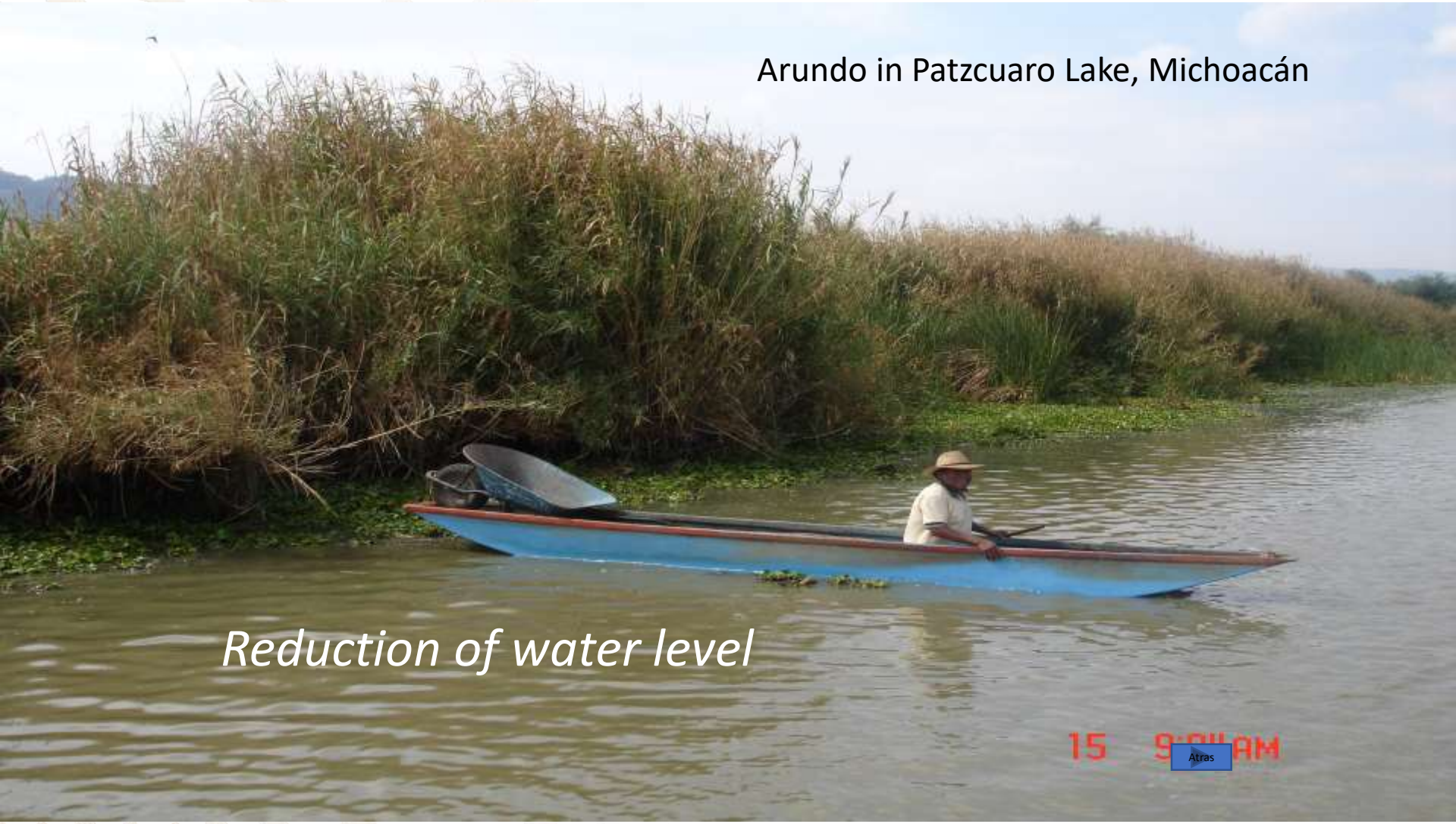

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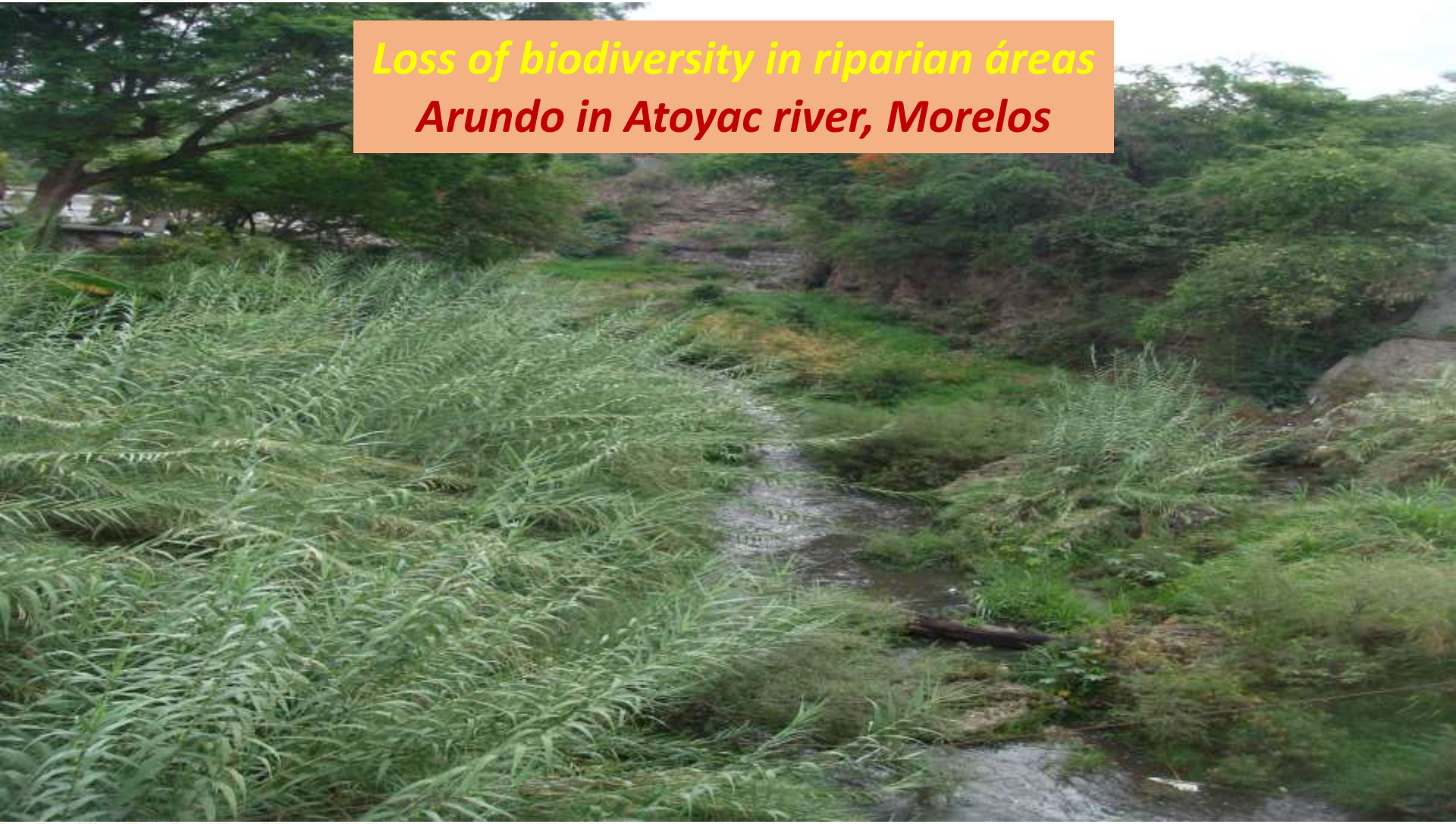

Loss of biodiversity in riparian áreas

Arundo in Atoyac river, Morelos

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Arundo infestation alongside roads

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Arundo donax in Tembembe river, Morelos México

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BINATIONAL MEETING, 2009
CILA/IBWC/USDA/IMTA

Nuevo Laredo, Tamaulipas

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Biological Control of *Arundo donax*

- Long-term, sustainable
- Low cost
- Environmentally friendly
- Bi-national agreement

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Arundo wasp
Tetramesa romana

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Arundo wasp, *Tetramesa romana*

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Arundo scale, *Rhizaspidiotus donacis* female under armor

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IMTA Facilities in Mexico for rearing Arundo wasp

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December 2009: First Release of Arundo wasp in Columbia, Nuevo Leon, Mexico

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Arundo wasp releases in Nuevo Laredo, Tamaulipas

May 2010 (5,100 wasp)
Jun (3,500 wasp)

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Arundo wasp and Arundo scale releases in Nuevo Laredo, Tamaulipas

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Arundo wasp and Arundo scale in Reynosa, Tamaulipas

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Release of the Arundo scale on Mexican side of Rio Grande

Binational Crew (USDA, CILA, IBWC)

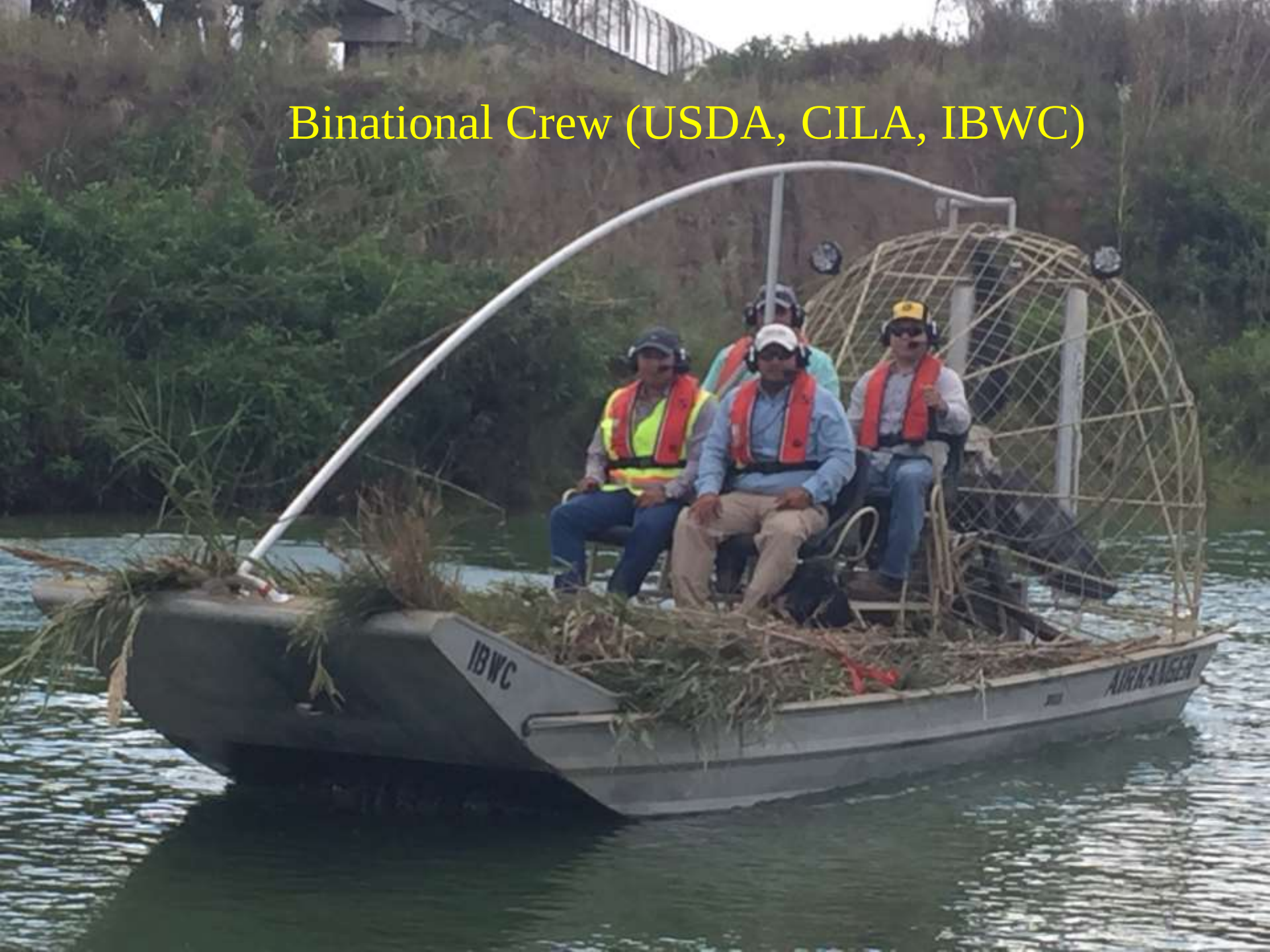

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Tabla 2: Establecimiento y Dispersión de *Tetramesa romana* en México

Sitio de Liberación	# orificios /m^2	WDS después de 6 meses	WDS después de 1 año
Morelos: Jiutipec N 18° 51.9' 4.0" W 99° 10.3' 18" N 18° 51' 59.0" W 99° 10' 16.4"	6 meses: 26 1 año: 65	WDS= 3	WDS= 4
Morelos: Alpuyeca N 18 ◦ 44.1':47'' W 99◦ 15.4':93'' N 18° 44' 7.5" W 99° 15' 27.6" N 18° 44' 11.0" W99° 15' 30.9"	6 meses: 19 1 año: 74	WDS= 3	WDS= 4
Morelos: Puente de Ixtla N 18° 38' 120" W 99° 19' 0.648"	6 meses: 31 1 año: 70	WDS= 3	WDS= 4
Nuevo Laredo, Tamaulipas N 27°27´00.8" W 99°29´42.4" N 27°27'00.4" W 99°29'42.2" W N 27°27´00.4" N W 99°29´42.6" W	6 meses: 34 1 año: 88	WDS= 4	WDS= 4

Wasp Dispersal Score (WDS): 0=no orificios; 1=orifiicos solo en el sitio de liberación; 2= orificios 100m alejados del sitio de liberación; 3= orificios 500m alejados del sitio de liberación; 4= orificios a más de 500m del sitio de liberación

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Introducción, Establecimiento y Dispersión en México de la avispa *Tetramesa romana*, agente de control biológico del carrizo gigante

Introduction, Establishment and Dispersion in Mexico of the wasp *Tetramesa romana* , a biological control agent of the Giant Reed

Author(s): Maricela Martínez Jiménez, John A. Goolsby, Alex E. Racelis, A. Perez de Leon, and David Negrete Arroyos.

Southwestern Entomologist, 42(2):427-434.
https://doi.org/10.3958/059.042.0213
URL: http://www.bioone.org/doi/full/10.3958/059.042.0213

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Summary

- Two biological control agents from Mediterranean Europe are now established in US and Mexico
- Arundo wasp and Arundo scale widespread and showing impact on landscape level
- A leafminer (*Lapsioptera donacis*) was released in USA, release in Mexico will be made in 2020
- Significant benefits to agricultural & municipal water users, national security, cattle production, natural environment and human health.

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Thank you - Gracías