Supplementary Material for ANDREW PAUL GUTIERREZ AND LUIGI PONTI−Prospective Analysis of the Geographic Distribution and Relative Abundance of Asian Citrus Psyllid (Hemiptera: Liviidae) and Citrus Greening Disease in North America and the Mediterranean Basin. Florida Entomologist 96(4) (December, 2013) at http://purl.fcla.edu/fcla/entomologist/browse

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ABSTRACT

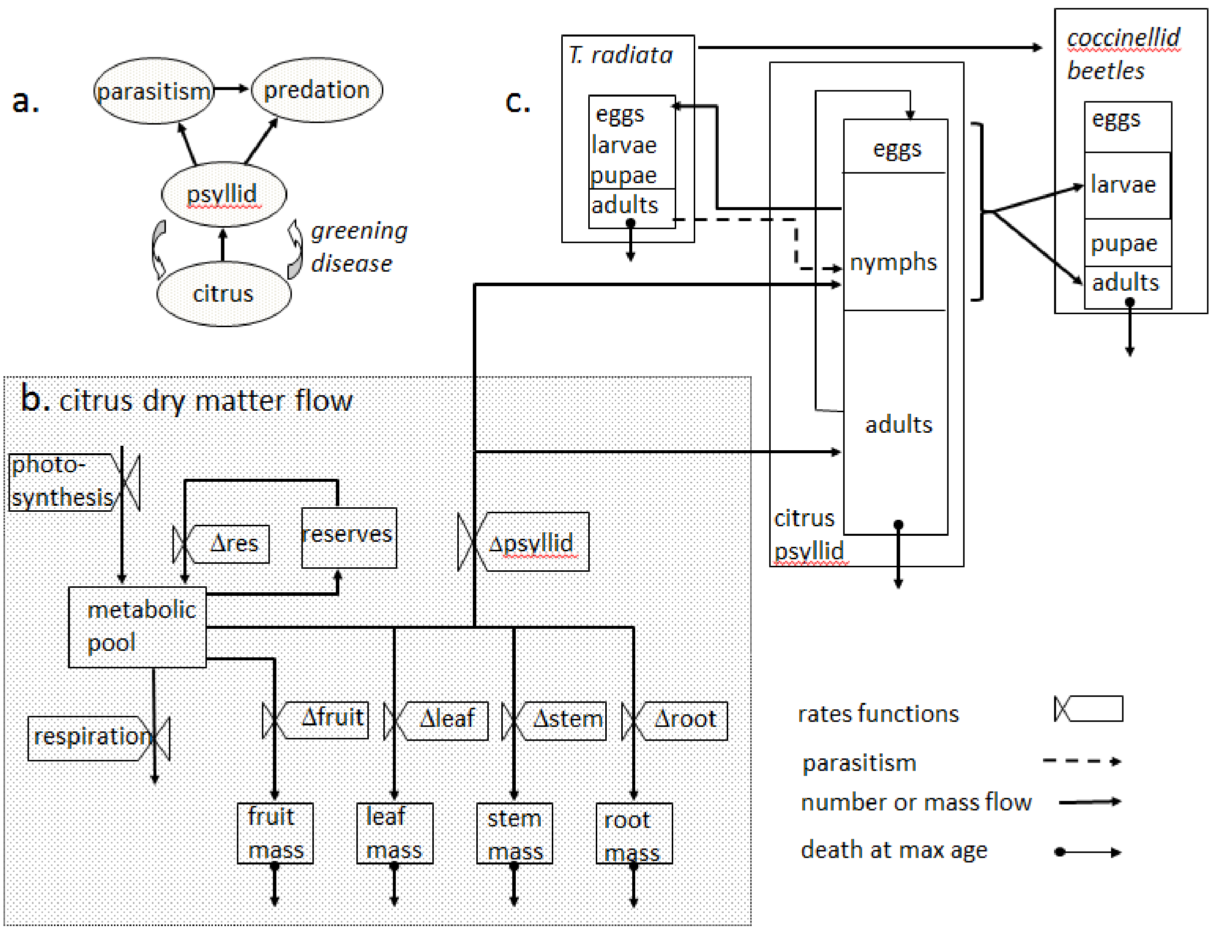
The invasive Asian citrus psyllid (*Diaphorina citri* Kuwayama) is the vector of the bacterial pathogen (‘*Candidatus* Liberibacter asiaticus’) that is the putative causal agent of citrus greening disease (Huanglongbing disease) in citrus in many areas of the world. The capacity to predict the potential geographic distribution, phenology and relative abundance of the pest and disease is pivotal to developing sound policy for their management. A weather-driven physiologically based demographic model (*PBDM*) system was developed to summarizes the available data in the literature, and used to assess prospectively the geographic distribution and relative yield of citrus, the relative densities of the psyllid, its parasitoid (*Tamarixia radiata* Waterston), and the potential severity of citrus greening disease in North America and the Mediterranean Basin. The potential for natural and biological control of citrus psyllid was examined prospectively.

Key Words: citrus, *Tamarixia radiata* , Huanglongbing disease, invasive species, GIS, population dynamics, modeling, biological control.

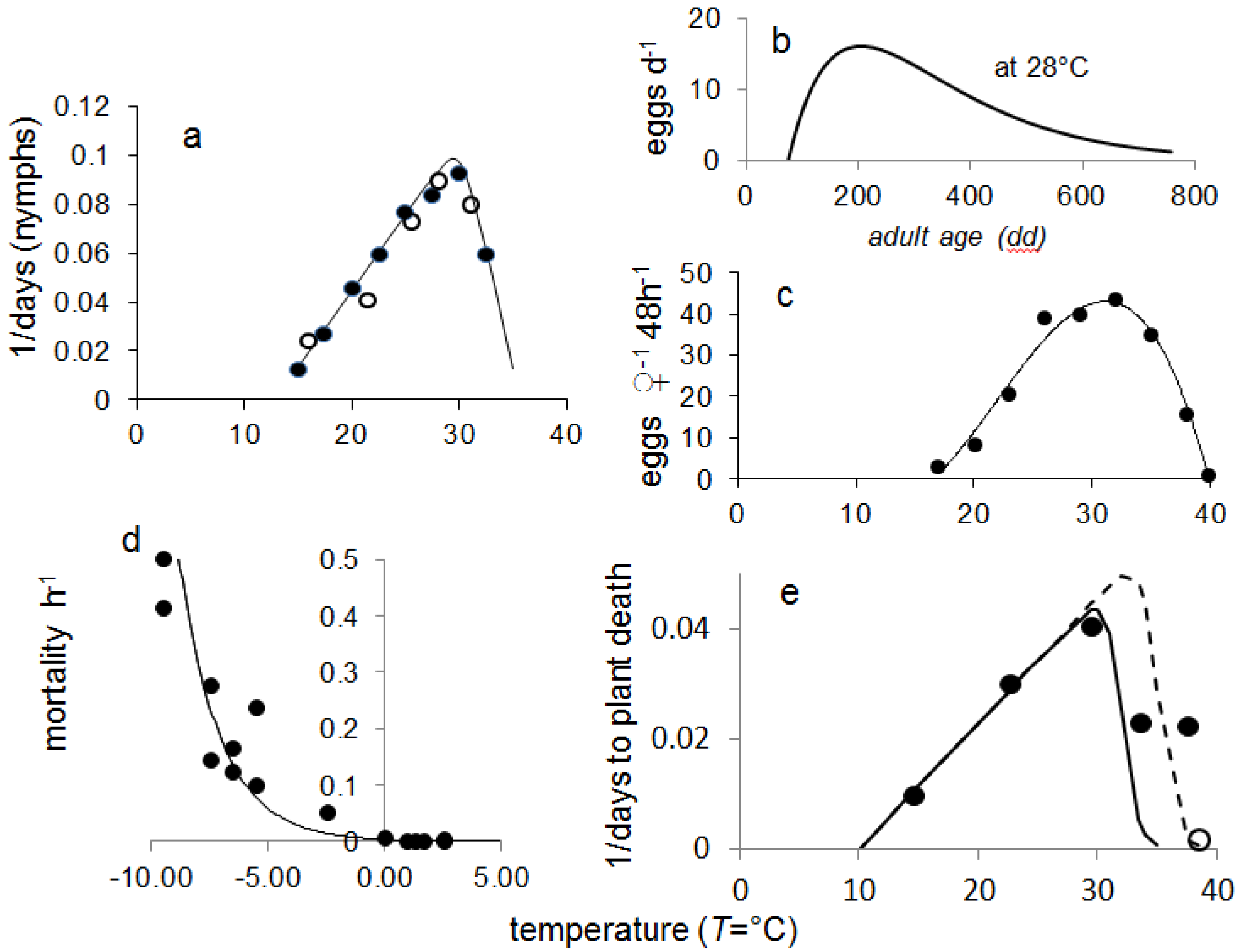
RESUMO

O psilídio asiático (*Diaphorina citri* Kuwayama 1908) invasor de citros e vetor do patógeno bacteriano (‘*Candidatus* Liberibacter asiaticus‘) é o agente causal putativo da doença huanglongbing (greening) dos citros em muitas áreas do mundo. A capacidade para prever o potencial de distribuição geográfica, a fenologia e a abundancia relativa desse vetor e da doença, é fundamental para o desenvolvimento de uma política adequada para o seu manejo. Um sistema de modelo demográfico com base fisiológica e acionado por condições climáticas foi desenvolvido e contém um resumo dos dados disponíveis na literatura, utilizados para avaliar de forma prospectiva a distribuição geográfica e a abundancia relativa dos citros, do psilídio, seu parasitoide (*Tamarixia radiata* Waterston) e da doença “greening” na América do Norte e na bacia do Mediterrâneo. O potencial para o controle natural e biológico do psilídeo dos citros é examinado de forma prospectiva.

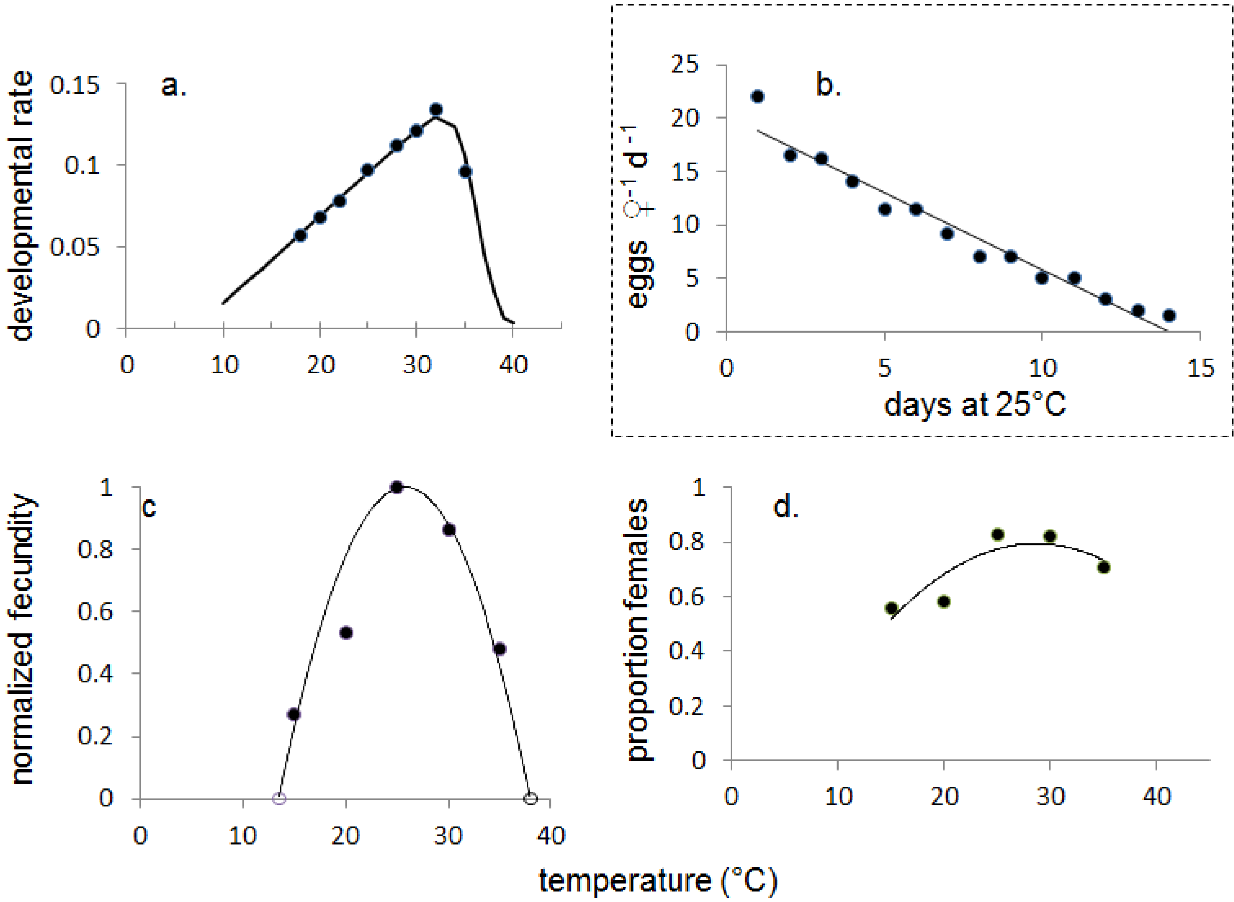
Palavras Chave: citros, *Tamarixia radiata* , doença huanglongbing, especies invasoras, GIS, dinâmica populacional, controle biológico



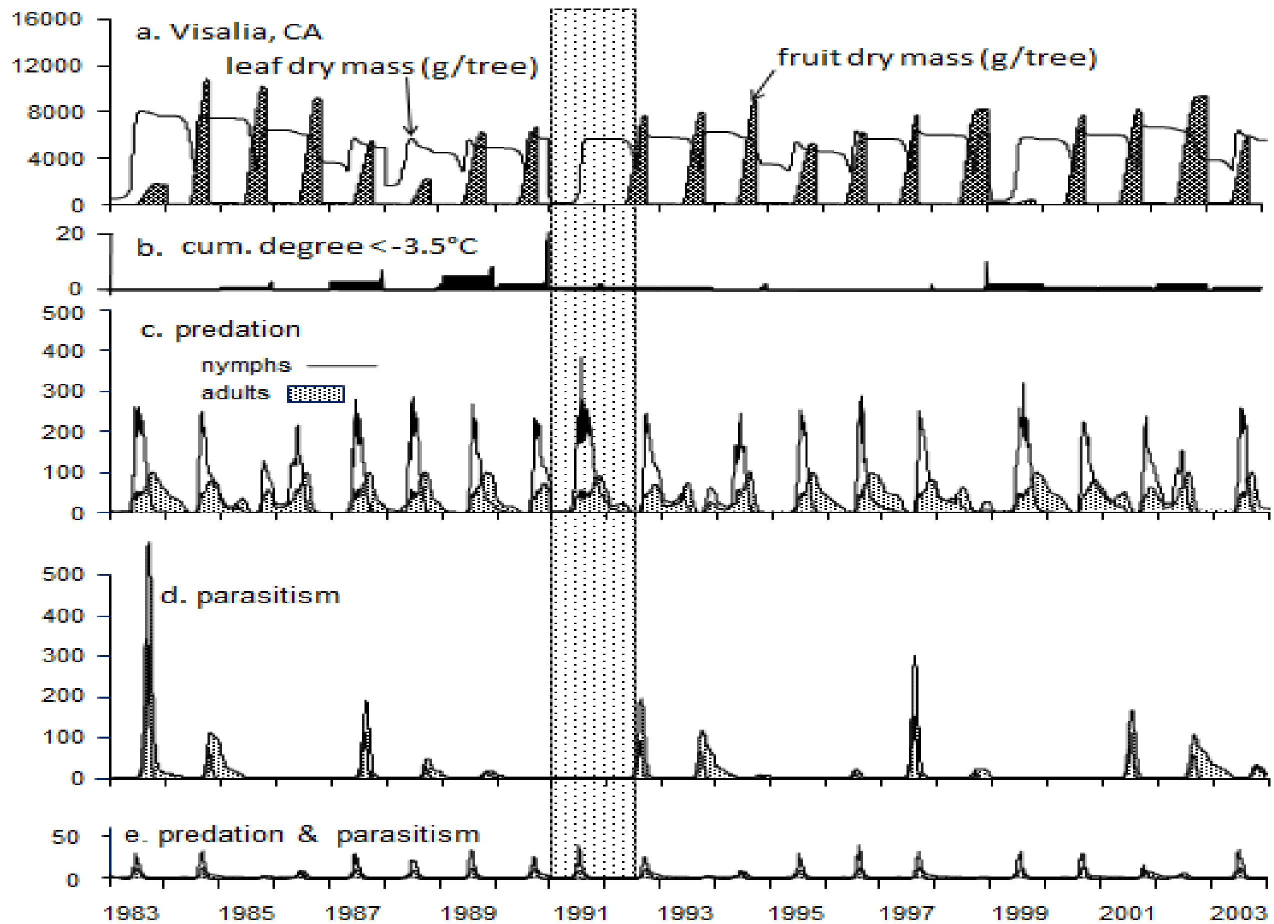
Suppl. Fig. 1. The citrus/citrus psyllid/parasitoid/disease system: (a) trophic relationships, (b) energy flow within citrus and to the psyllid, and (c) th biology of the psyllid and its natural enemies (the parasitoid *Tamarixia radiata* and coccinellid beetles).



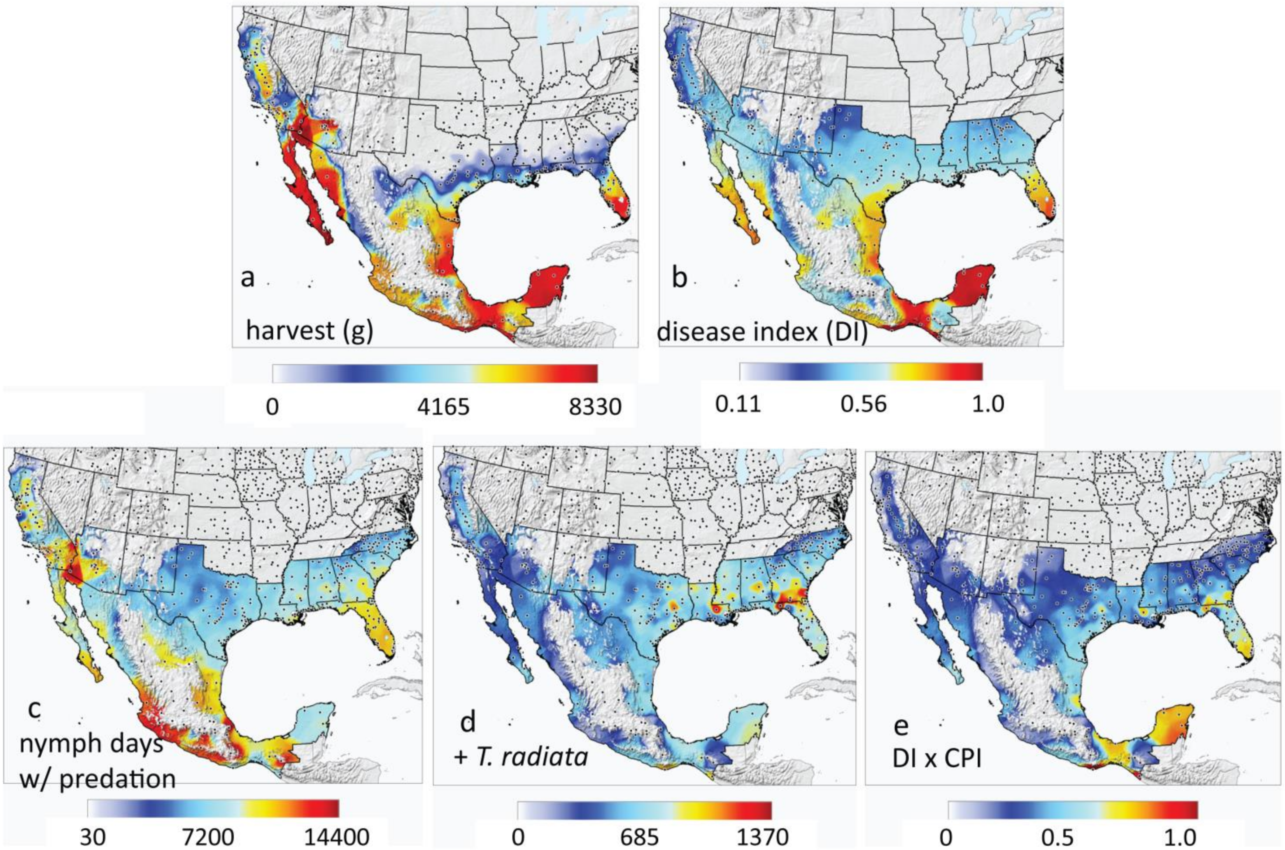
Suppl. Fig. 2. The biology of citrus psyllid (a-d) and greening disease (e): (a) the developmental rate per day of *Diaphorina citri* on temperature [(Liu & Tsai 2000 (○); Nakata 2006 (●)], (b) the age specific fecundity profile at 28 ºC (Liu & Tsai 2000), (c) the effect of temperature on psyllid egg production (Hall et al. 2011), (d) psyllid mortality rate per hour at low temperatures (Tsukuba 2007; Hall et al. 2011; see text), and (e) the reciprocal of time to plant death in potato due '*Ca.* Liberibacter solanacearum' ((●, ——), Munyaneza et al. 2012), and estimates for '*Ca.* Liberibacter asiaticus' development in citrus (○, - - - -) based on observations from Bové (2006) and Lopes et al. (2009).



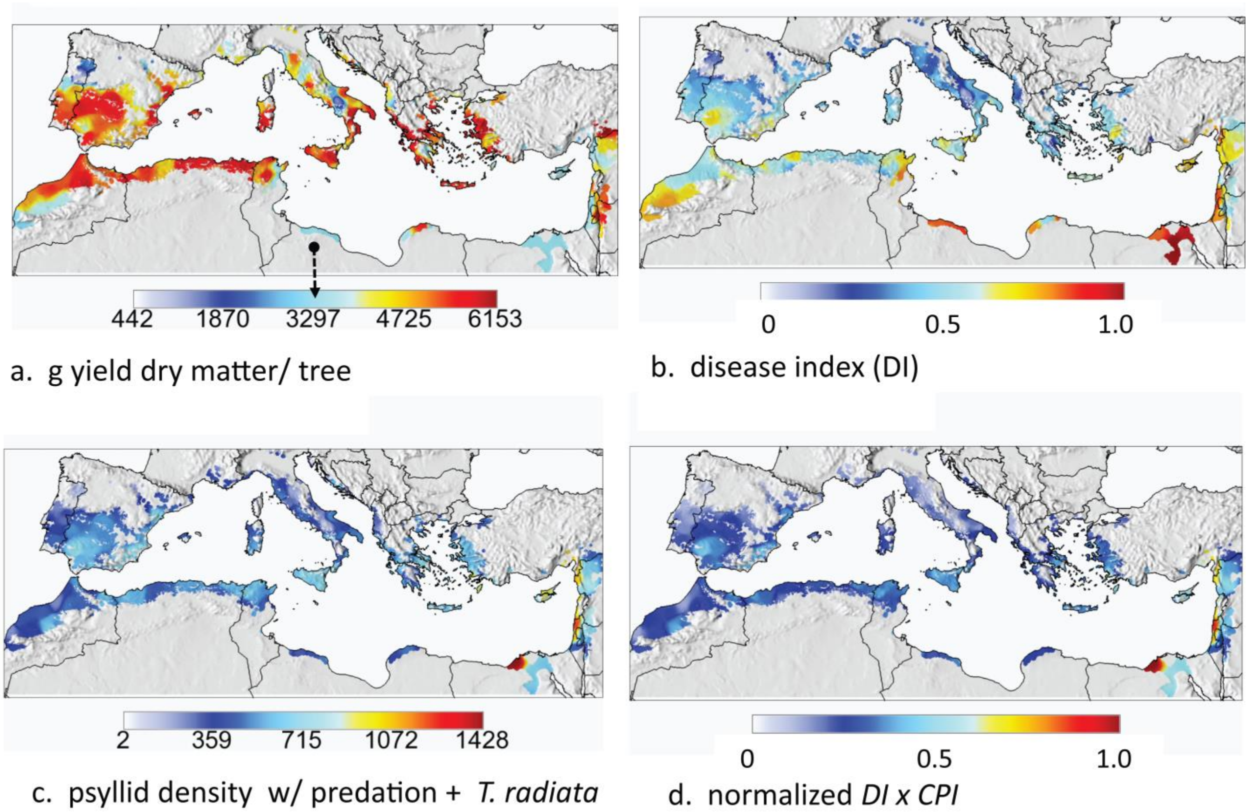
Suppl. Fig. 3. Biology of *Tamarixia radiata*: (a) rate of development per day on temperature for the egg-pupal period, (b) per capita fecundity profile for females of age (x) in days at 25 °C, (c) normalized fecundity on temperature, and (d) the proportion females at 5 day average temperature $\bar{T}$ (data from Gómez-Torres 2009 and Gómez-Torres et al. 2012, see also Parra et al. 2010).



Suppl. Fig. 4. The simulated dynamics of the citrus/*Diaphorina citri* system at Visalia, California for the period 1983 to 2003: (a) leaf and fruit dry matter growth dynamics (g), (b) cumulative degree days below -3.5C, and *D. citri* dynamics: (c) with only predation, (d) with only parasitism, and (e) with both predation and parasitism. The stippled vertical area indicates a period following freezing temperature that affected all species in the system (see text).



Suppl. Fig. 5. The simulated average dynamics of the citrus/citrus psyllid/greening disease system across North America below 1500m: (a) simulated yield in g dry matter per tree, (b) the normalized growth rate of greening disease (*DI*), (c) psyllid nymph days per tree given the effects of coccinellid predation, (d) psyllid nymph days per tree given the added effects of *Tamarixia radiata* parasitism, and (e) the product of *DI* and the normalized psyllid density (i.e., *CPI*) computed from the data used in Fig. 5d.



Suppl. Fig. 6. The simulated average dynamics of the citrus/citrus psyllid/greening disease system across the Mediterranean Basin below 1000m: (a) simulated yield in g dry matter per tree, (b) the normalized cumulative growth rate of greening disease (*DI*), (c) psyllid nymph days per tree given the effects of coccinellid predation and *Tamarixia radiata* parasitism, and (d) the product of *DI* and normalized psyllid density (i.e., *CPI*) computed from data used in Fig. 6c.