Effects of prey availability and climate across a decade for a desert-dwelling, ectothermic mesopredator

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Trophic interactions in desert systems are presumed to be strongly linked, hence:

Annual trophic patterns in desert scrub communities are expected to be strongly influenced by annual variation in temperature and precipitation.

Thus, short term effects of climate on desert scrub communities are expected as *bottom-up effects* in production:

- **plants to herbivores (1^{o} C)**
- **herbivores to predators (2^{o} C)**
- **2^{o} C to mesopredators & apex predators (3^{o} C).**

The hypothesized bottom-up effects in production can be tested by correlational analyses of

- **body condition of a 3^o C lizard,**
- **3^o consumer abundance among years,**
- **annual productivity of the lizard's prey,**
- **Annual (short-term) climatic patterns in temperature and precipitation.**

Subject Animals

- **Apex-like mesopredator as 3^o consumer*:**
  - **Leopard Lizard, *Gambelia wislizenii***
- **Insectivores as 2^o consumers*:**
  - **Western Whiptail Lizard, *Aspidoscelis tigris***
  - **Desert Horned Lizard, *Phrynosoma platyrhinos***
- **Insects as 1^o consumers*:**
  - **Grasshoppers, ants, caterpillars, and more**

***obviously, trophic levels are mixed for many animals**

Male leopard lizard, *Gambelia wislizenii* in classic ambush predation pose.

It eats large arthropods, especially grasshoppers, and other lizards.

Prey of the leopard lizard, ***Gambelia wislizenii***

Marked female *Gambelia wislizenii* eating western whiptail lizard, *Aspidoscelis tigris*.

Research Site

- **Alvord Basin, Harney Co, OR**

- **BLM administered public land**

- **Great Basin desert scrub**
    - **20% cover by perennial vegetation**
    - **Mix of sandy flats, dunes, and hardpan mesohabitats**

- **Dominant perennial shrubs:**
    - **Basin big sage, *Artemisia tridentata***
    - **Greasewood, *Sarcobatus vermiculatus***

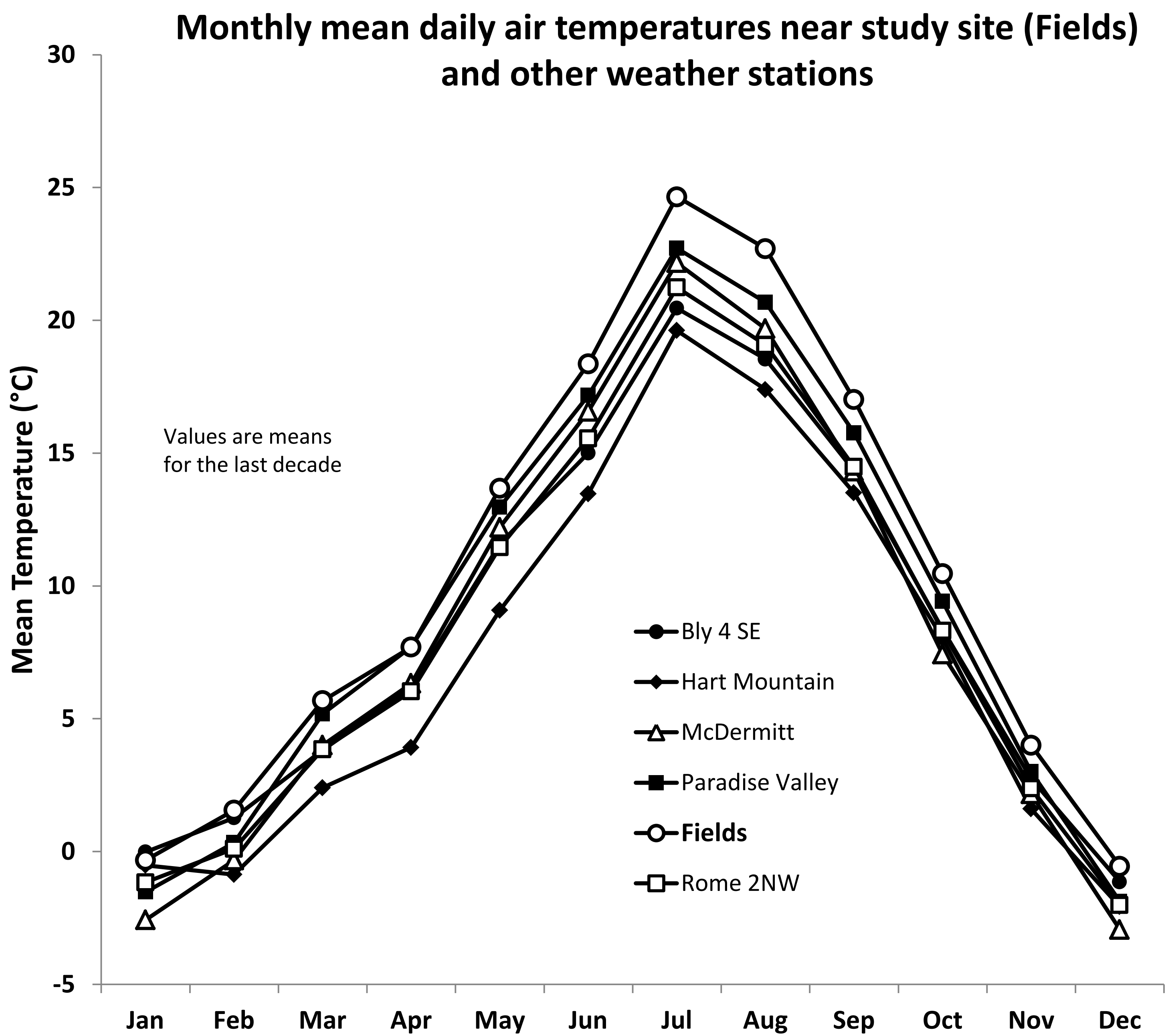
On plot, view northward of Alvord Basin, with Steens Mountain, June 2011.
(note the extensive cheatgrass in foreground)

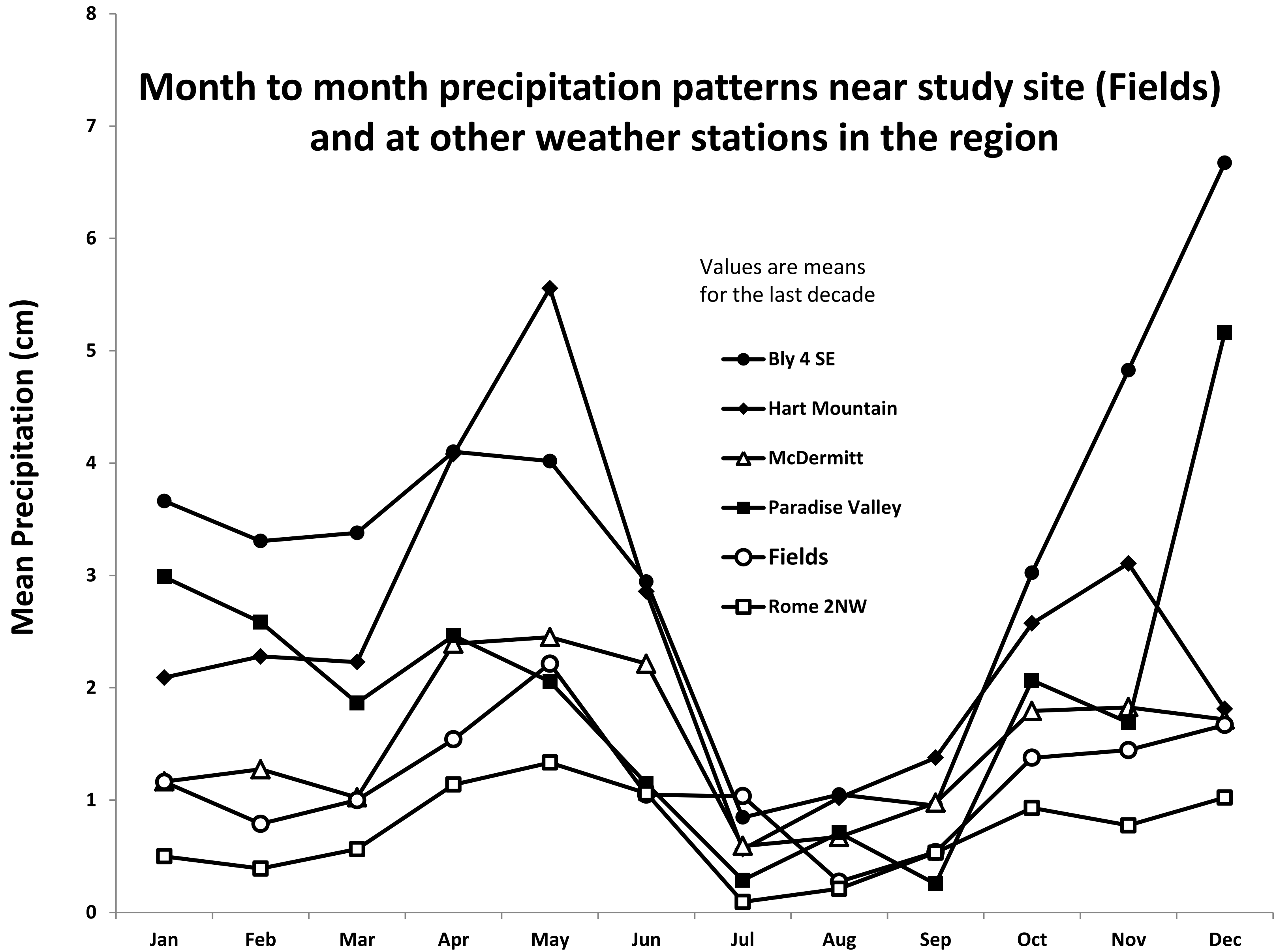
Methods

- **Research period ~June 25 to July 16, 2003-2012**
- **Standard plot surveys for grasshoppers**
- **Standardized annual pitfall trapping**
- **Annual census of lizards on a 4 ha core plot**
- **Capture-mark-release of more lizards near plot**
- **Weather records in the field, buttressed from weather station in nearby Fields, OR, compiled by the DRI, under auspices of WRCC.**

Methods

- **Annual arthropod counts from pitfall traps**
  - ➢ **In 2012: 168 pairs of pitfall traps caught**
    - ➢ **28851 macroarthropods**
      - ➢ **11642 ants**
      - ➢ **6354 non-ant walkers & perchers**
      - ➢ **10855 flight-prone insects**
- **Annual grasshopper counts**
  - – **3 count episodes per plot per time of day**
  - – **3 times of day, across 9 days (~1 per day per plot),**
  - – **Eight 5m x 5m quadrats per each 10m x 40m plot,**
  - – **3 plots per mesohabitat,**
  - – **3 prevalent mesohabitats.**


Monthly mean daily air temperatures near study site (Fields) and other weather stations
Mean Temperature (°C)
30
25
20
15
10
5
0
-5
Values are means for the last decade
Bly 4 SE
Hart Mountain
McDermitt
Paradise Valley
Fields
Rome 2NW
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec



Month to month precipitation patterns near study site (Fields)
and at other weather stations in the region
Values are means
for the last decade
Bly 4 SE
Hart Mountain
McDermitt
Paradise Valley
Fields
Rome 2NW
Mean Precipitation (cm)
0
1
2
3
4
5
6
7
8
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

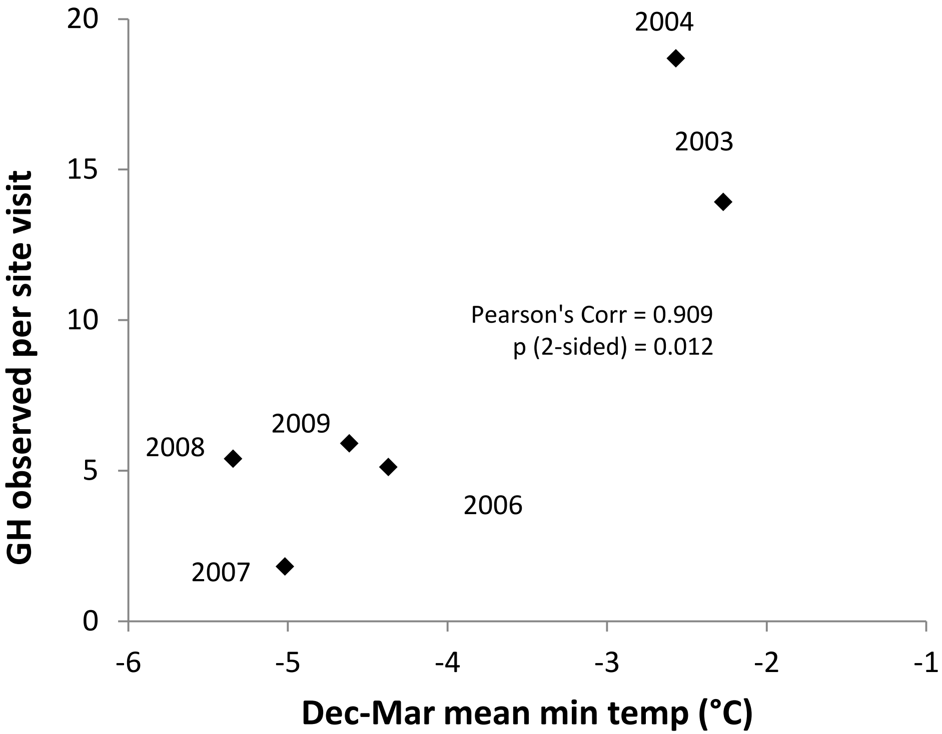
Four dominant grasshoppers on plot, 2003-2009

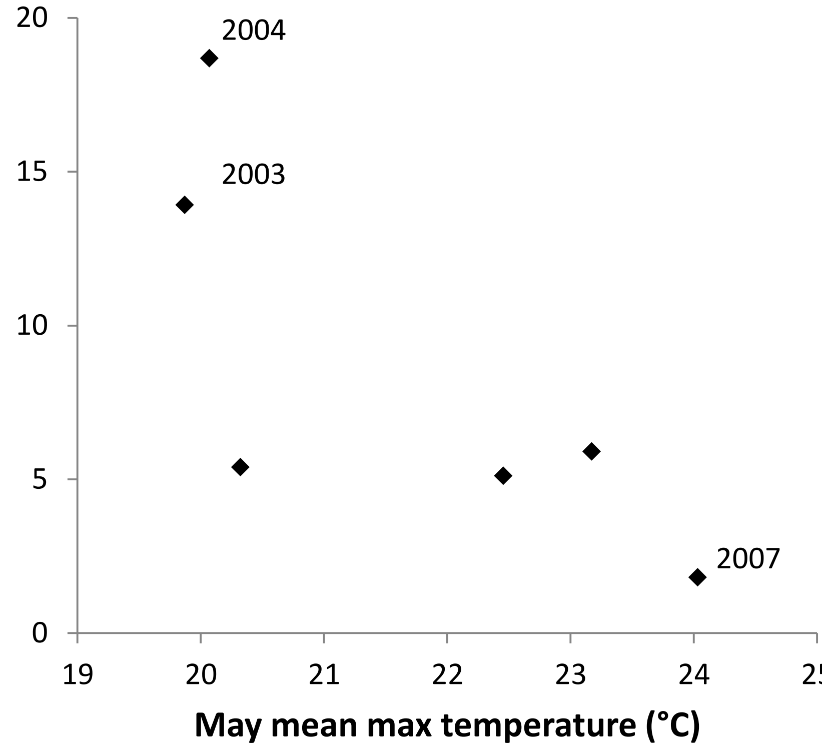
	Proportion (mean)
Trimerotropis pallidipennis (Pallid winged gh)	0.51
Cordillacris occipitalis (Spotted winged gh)	0.29
Melanoplus rugglesi (Nevada sage gh)	0.09
Parapomala pallida (Mantled toothpick gh)	0.07

Sample sizes:

Values are means from 3 counts for each for 2-3 time periods, for each of 9 days on eight 5mx5m quadrats, with 8 quadrats per 10mx40m plot , 3 plots per meso habitat, per two mesohabitats.

Annual variation in number of grasshoppers counted on plot in early July, as related to air temperatures in prior months

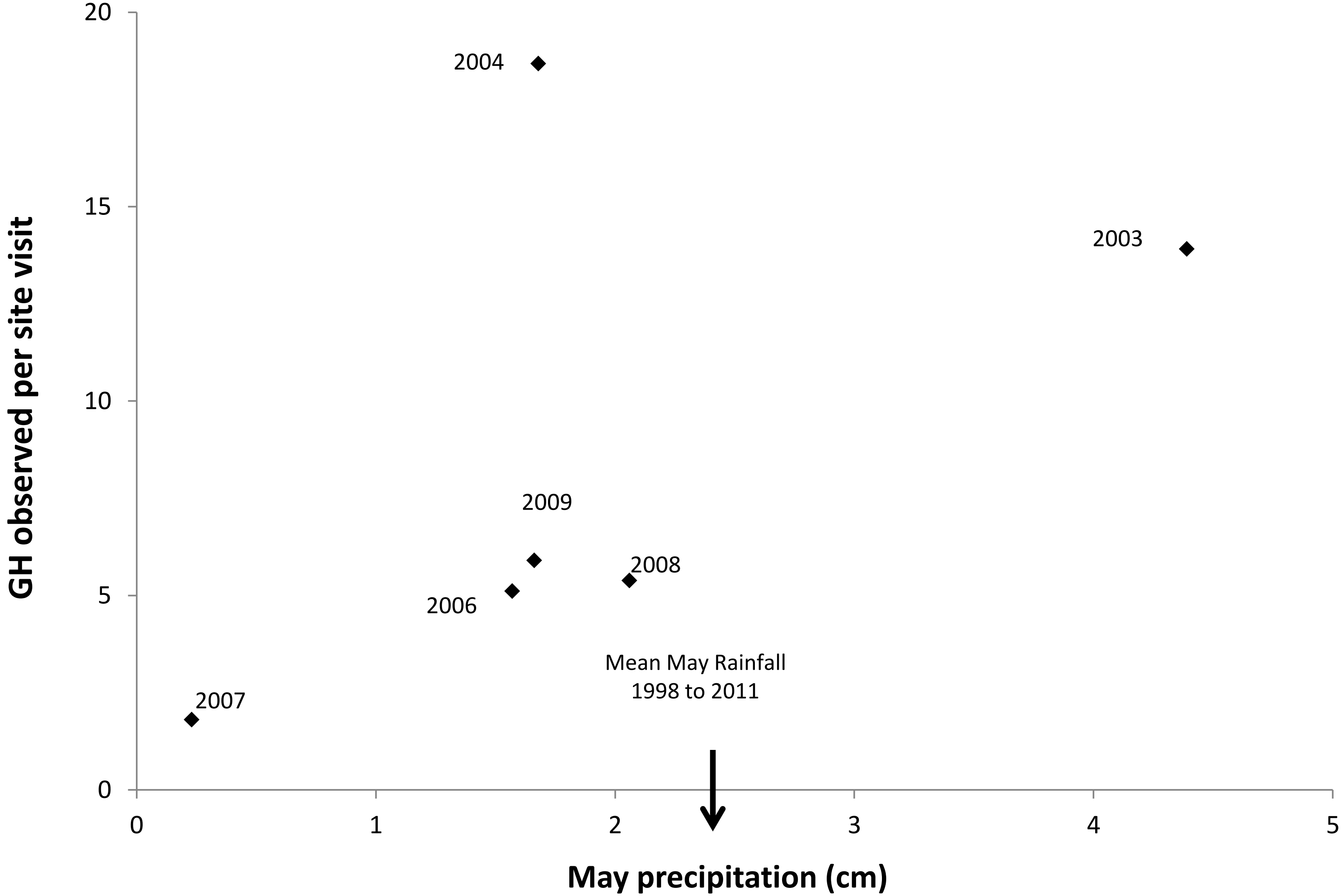




Sample sizes:

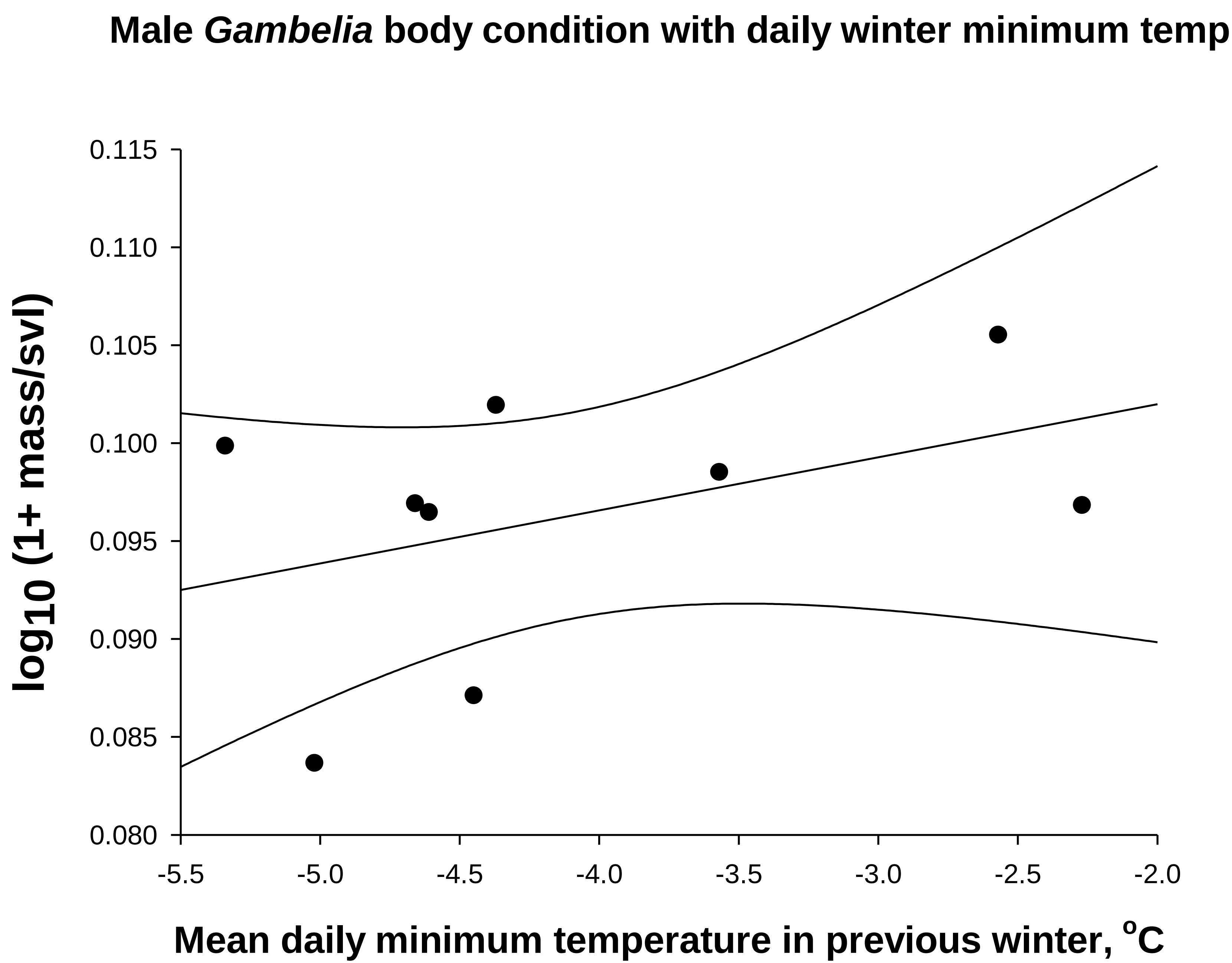
Values are means from 3 counts for each for 2-3 time periods, for each of 9 days on eight 5mx5m quadrats, with 8 quadrats per 10mx40m plot , 3 plots per meso habitat, per two mesohabitats.

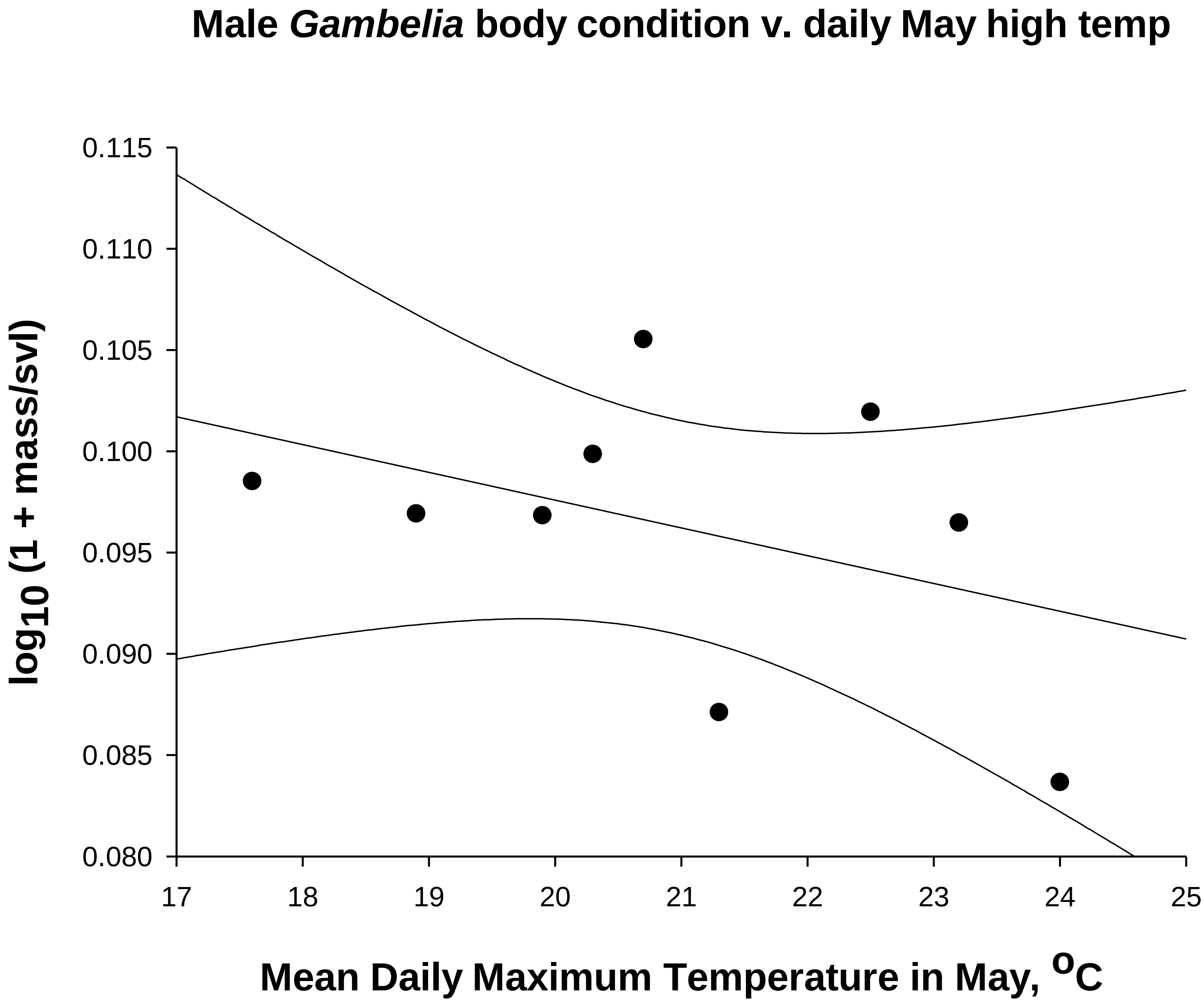
Annual variation in number of grasshoppers counted on plot in early July relative to the amount of May rain



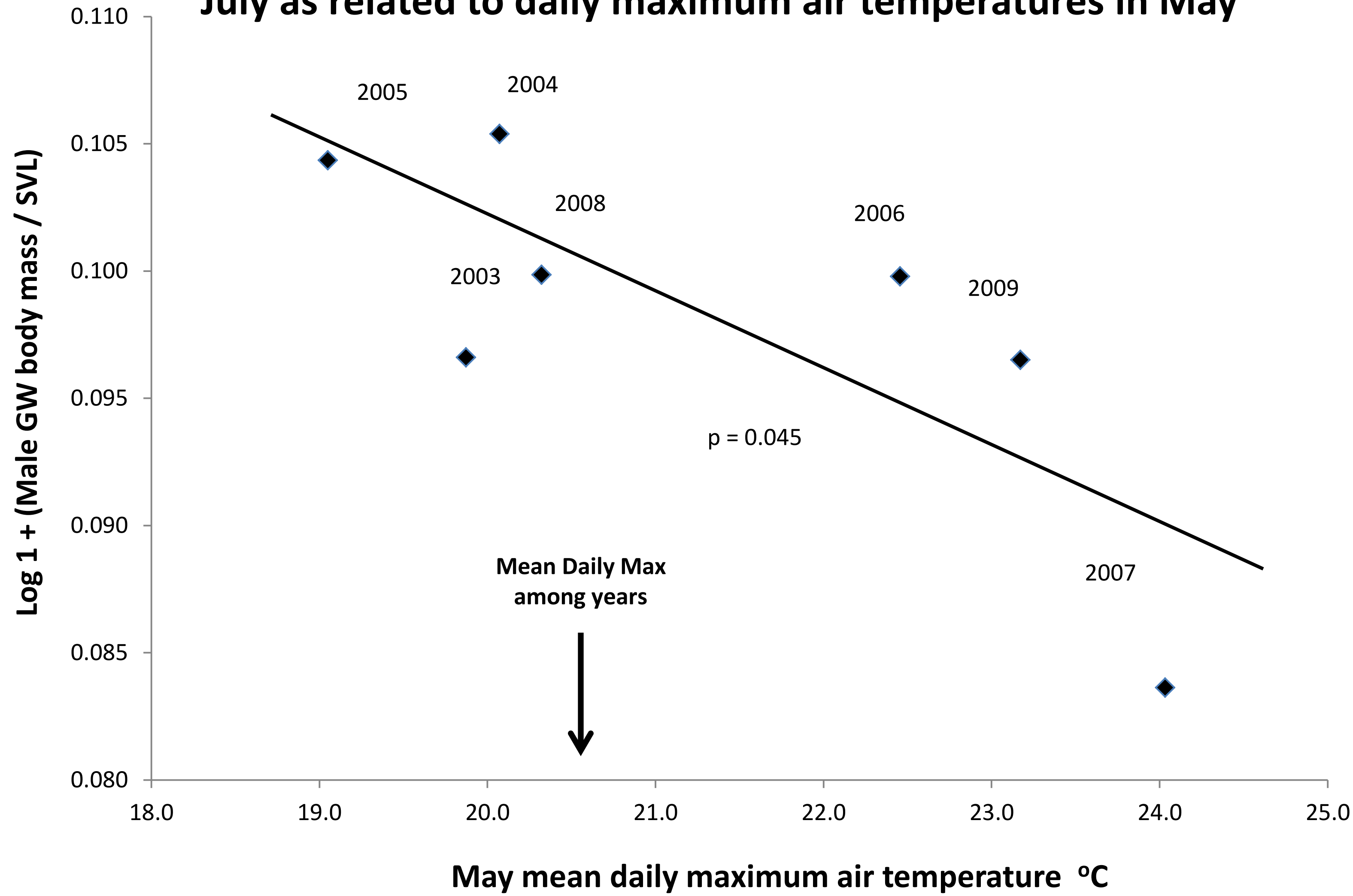
Sample sizes:

Values are means from 3 counts for each for 2-3 time periods, for each of 9 days on eight 5mx5m quadrats, with 8 quadrats per 10mx40m plot , 3 plots per meso habitat, per two mesohabitats.


Male Gambelia body condition with daily winter minimum temp
log10 (1+ mass/svl)
0.115
0.110
0.105
0.100
0.095
0.090
0.085
0.080
-5.5
-5.0
-4.5
-4.0
-3.5
-3.0
-2.5
-2.0
Mean daily minimum temperature in previous winter, oC

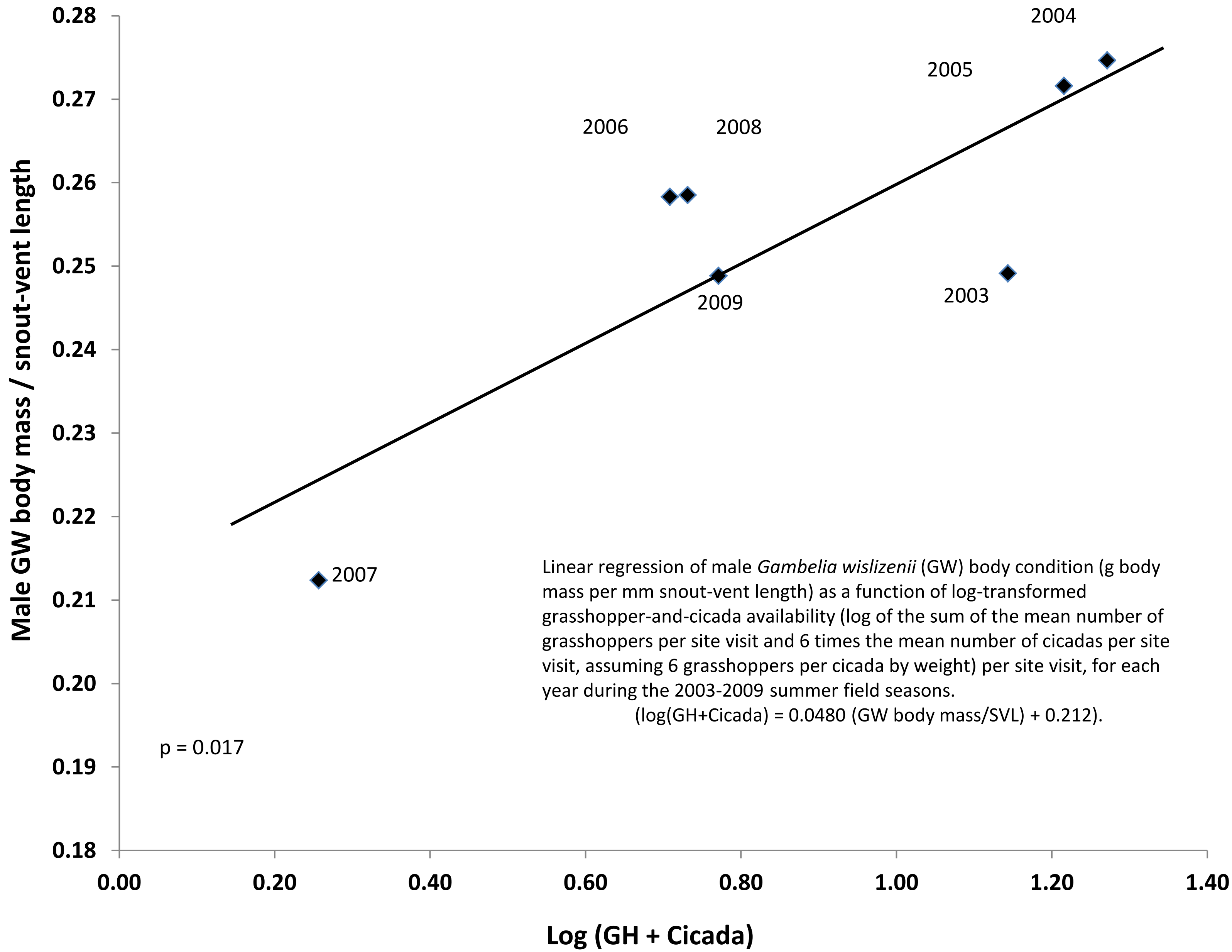

Male *Gambelia* body condition v. daily May high temp
0.115
0.110
0.105
0.100
0.095
0.090
0.085
0.080
17
18
19
20
21
22
23
24
25
$\log_{10}$ (1 + mass/svl)
Mean Daily Maximum Temperature in May, ^{o}C

Among year patterns of body condition of male leopard lizards in July as related to daily maximum air temperatures in May



Linear regression of log-transformed body mass to snout-vent length ratio of *Gambelia wislizenii* for each year during the 2003-2009 summer field seasons relative to the mean daily maximum temperature during the preceding May. Numbers for *G. wislizenii* body mass/snout-vent length ratio were transformed by adding 1, then taking the log of each data point [log(1+(GW body mass/SVL)) = 0.159 – 0.00289(Temperature)].

Body condition of male *Gambelia wislizenii* as presumed function of availability of its primary arthropod prey



Spearman Rank Analysis of factors affecting lizard body condition

Male Gw Mass/SVL	G-hopper Counts	G-hopper + May weather	May Max Temps	May Rain	Winter Min Temps
0.249(5)	13.9(2)	5(1)	19.9(1)	2(1)	-2.27(1)
0.275(1)	18.7(1)	8(2)	20.1(2)	5(2)	-2.57(2)
0.258(3)	5.1(5)	17(4.5)	22.5(4)	9(4.5)	-4.37(3)
0.212(6)	1.8(6)	23(6)	24.0(6)	12(6)	-5.02(5)
0.259(2)	5.4(4)	13(3)	20.3(3)	5(3)	-5.34(6)
0.250(4)	5.9(3)	17(4.5)	23.2(5)	9(4.5)	-4.61(4)
r_s	0.901*	0.887*	0.890*	0.868*	0.813

Asterisks denote significant correlations at N = 6 and α = 0.05 ($r_s > 0.829$).

Patterns of Arthropod Abundance in Pitfall Traps 2004-2011

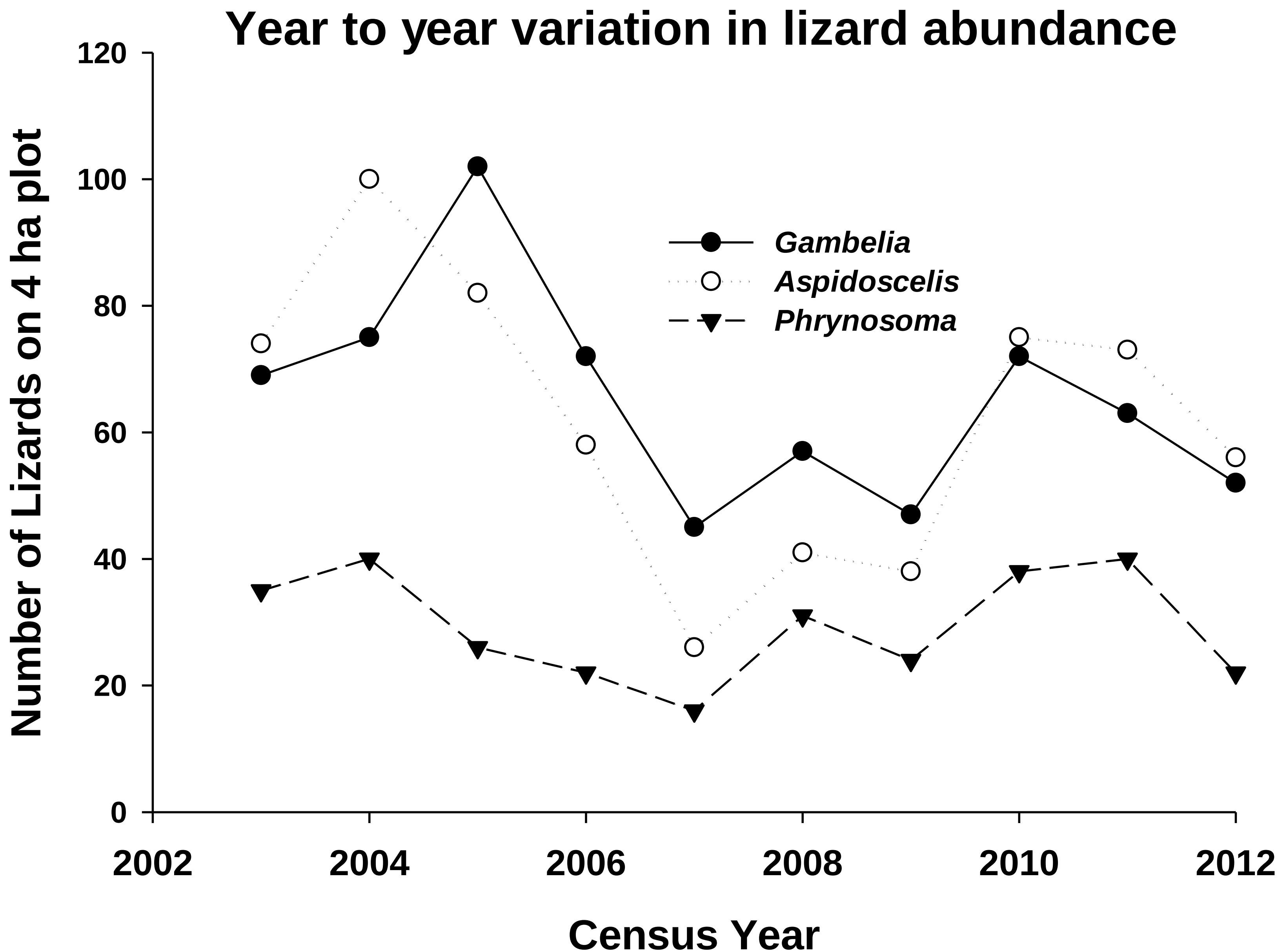
Analysis of Variance*

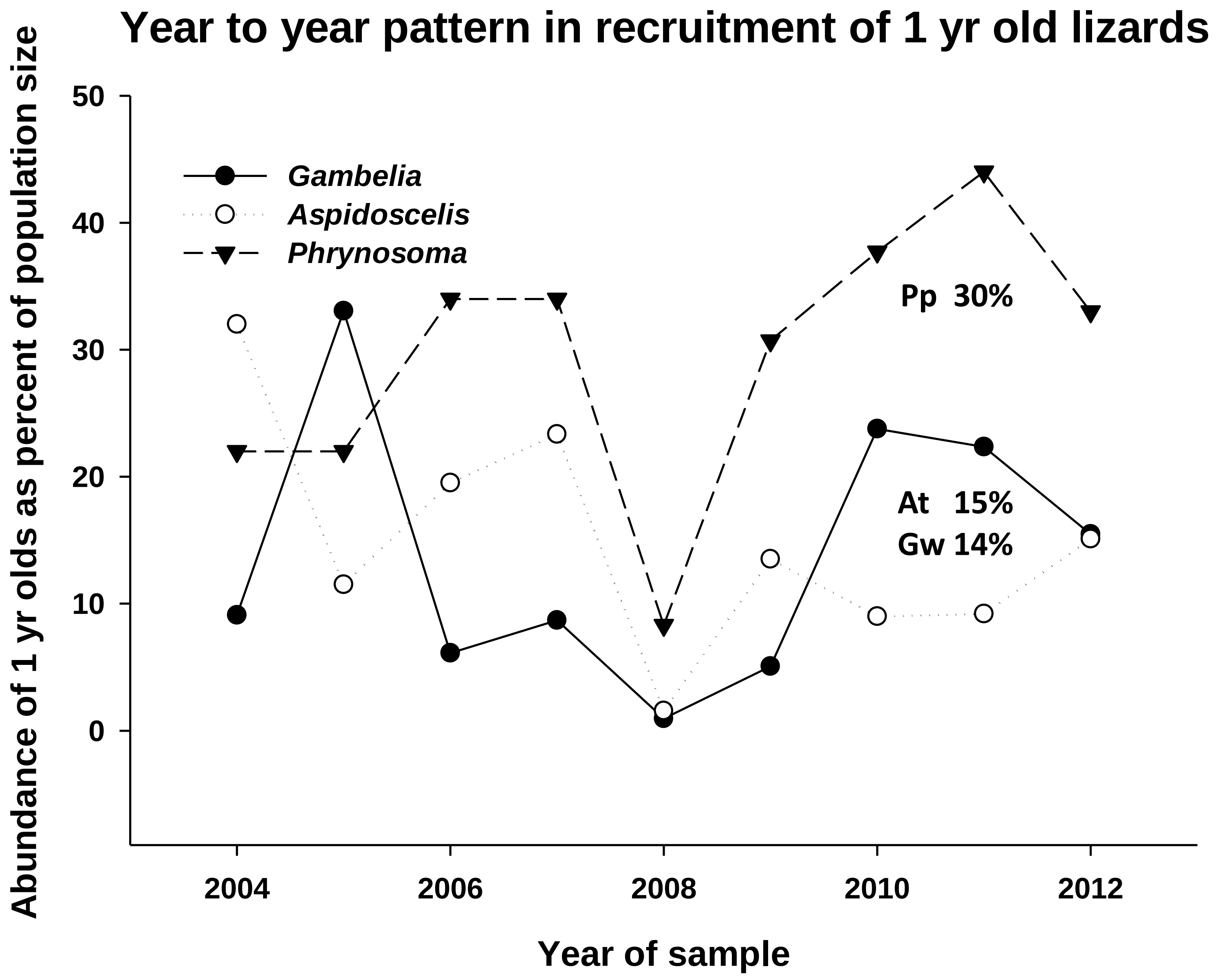
Source	Type III SS	df	Mean Squares	F-ratio	p-value
Year	357,964.706	7	51,137.815	75.328	0.0001
Mesohabitat	31,120.345	2	15,560.172	22.921	0.0001
Plant Species	10,577.248	1	10,577.248	15.581	0.0001
Plant Size	2,503.398	2	1,251.699	1.844	0.159
Error	494,893.417	729	678.866		

***Post hoc tests revealed these significant differences in annual abundances:**

Higher in 2005, 10, and 11 relative to 2004, 06-09

Rainfall total in both May 2010 & 2011 were about 3.75 cm

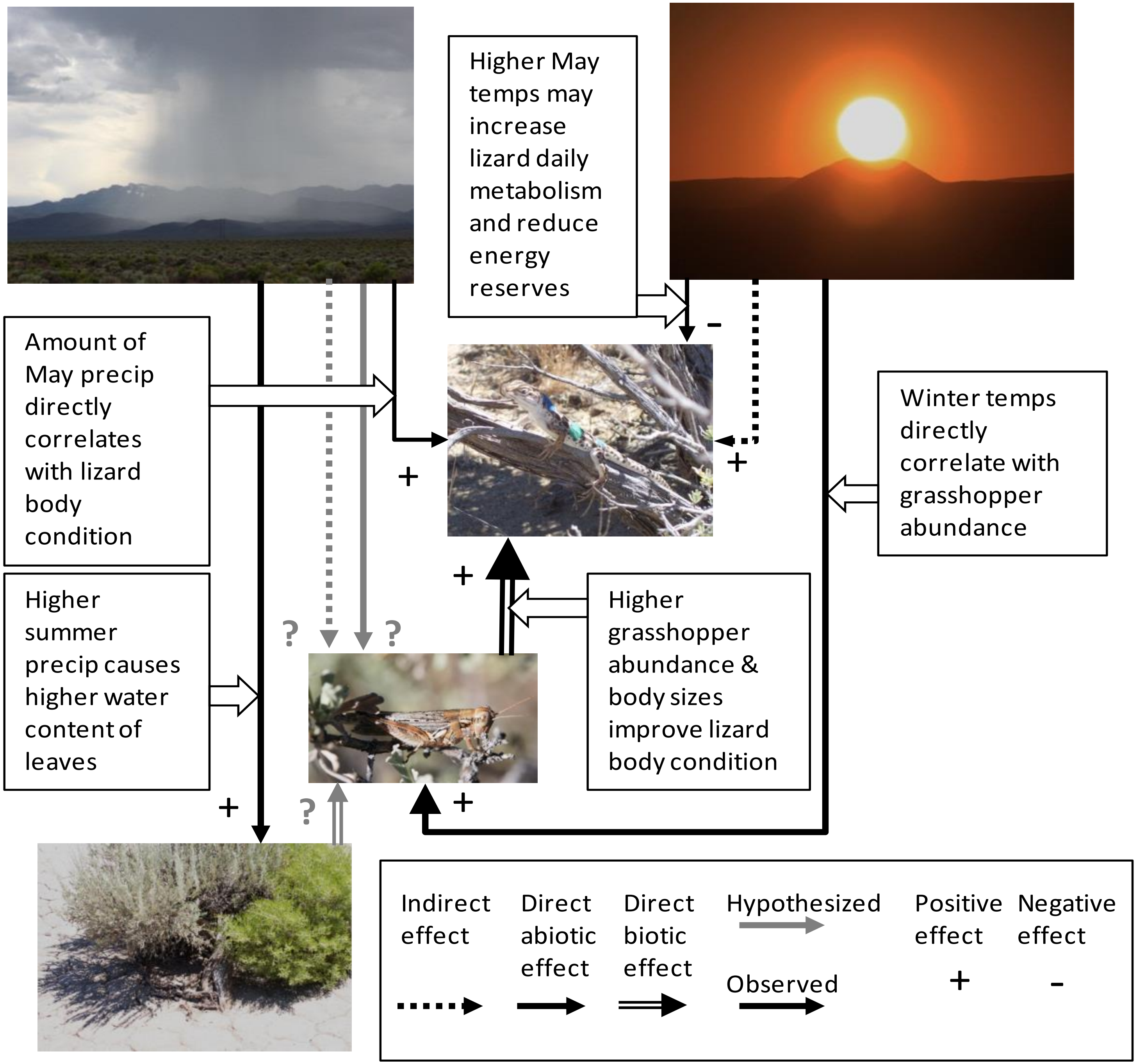

Year to year variation in lizard abundance
Number of Lizards on 4 ha plot
Census Year
0
20
40
60
80
100
120
2002
2004
2006
2008
2010
2012
Gambelia
Aspidoscelis
Phrynosoma



Year to year pattern in recruitment of 1 yr old lizards
Abundance of 1 yr olds as percent of population size
Year of sample
Gambelia
Aspidoscelis
Phrynosoma
Pp 30%
At 15%
Gw 14%
50
40
30
20
10
0
2004
2006
2008
2010
2012

Conclusions

- Short term climatic extremes in both the inactivity season and activity season may have a direct effect on arthropod prey abundance.
- Short term climatic variation in temperature and rainfall results in similar temporal variation of productivity at the lower trophic levels.
- Productivity at the lower trophic levels affect productivity at higher trophic levels.
- Higher temperatures during daily and seasonal inactivity periods may have debilitating energetic consequences for mesopredators and apex predators in seasonal environments, particularly if precipitation is low and the bottom-up trophic energy flow is slowed.
- More detailed and integrative analyses of the population dynamic patterns of the mesopredator, its vertebrate prey, and their prey may provide further insights to desert trophic interactions.
- See the next figure for summary of the interactions



Higher May temps may increase lizard daily metabolism and reduce energy reserves
-
+
Amount of May precip directly correlates with lizard body condition
+
Winter temps directly correlate with grasshopper abundance
+
Higher summer precip causes higher water content of leaves
?
?
Higher grasshopper abundance & body sizes improve lizard body condition
+
?
+
Indirect effect
Direct abiotic effect
Direct biotic effect
Hypothesized
Observed
Positive effect
+
Negative effect
-