Ecosystem Services for Crop Protection in Bean Fields along the Slopes of Mt. Kilimanjaro, Northern Tanzania

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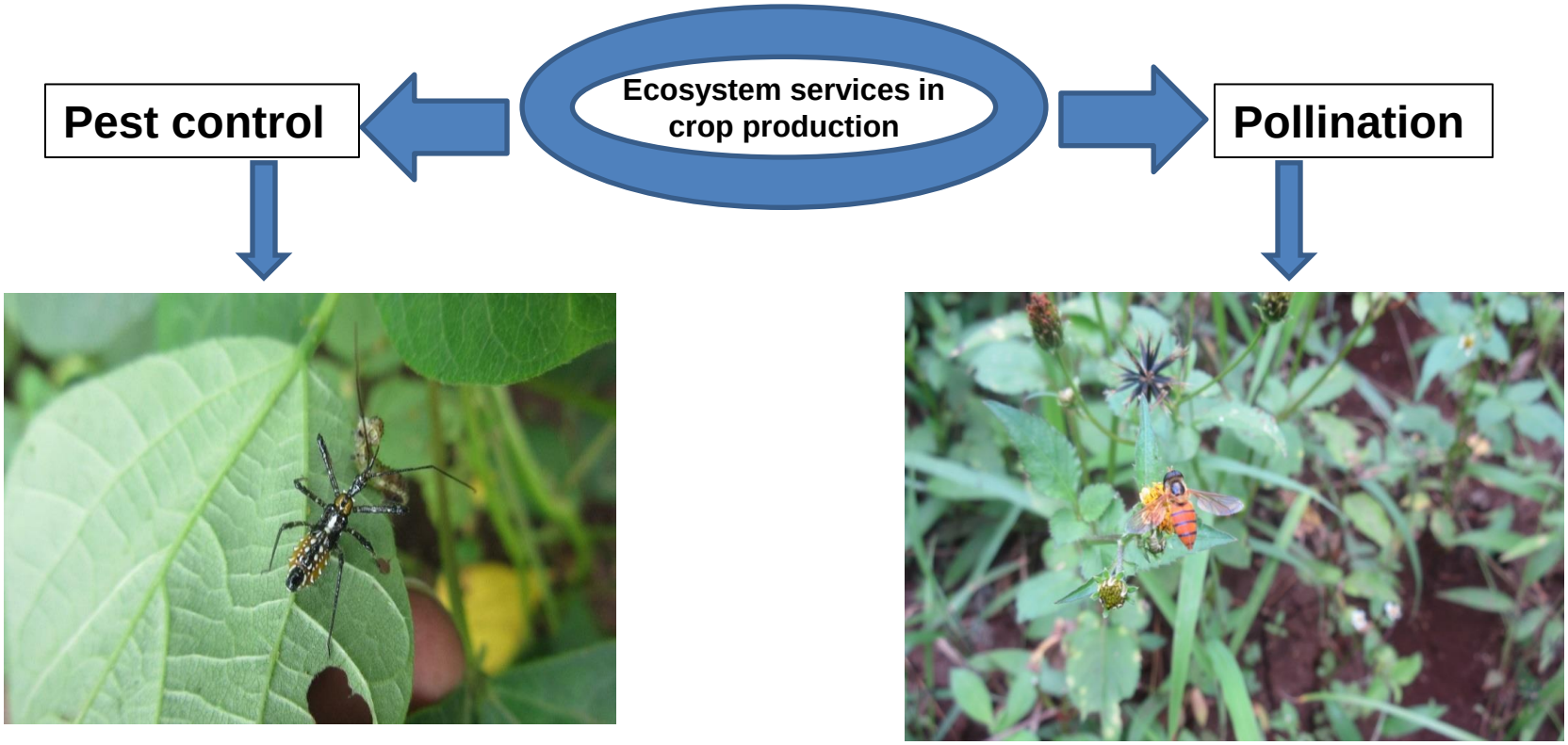
▪Agro-Ecosystem services



- Challenged by limited understanding in (*our small-scale*) African farming systems
- This study focused on identification of beneficial insects with associated plants and influential environmental factors in bean farming systems on the slopes of Mt. Kilimanjaro.

Harnessing agricultural ecosystem biodiversity for bean production and food security

Field margins support crucial ecosystem services

Pollinators and other beneficial insects require **food** when crops not flowering.

Wasps **parasitize** aphid but adults feed on nectar

Farmers extract field margin plants to use as **pesticide**.

Field margin plants also support **pests**

Some field margin species support beneficial insects but are also **pesticidal**

managing plant species could enhance their delivery

Background

- Insects and diseases spread by them are the major biotic production constraints in legume production

- Pesticides control insects but rarely used (costs and availability) and are harmful to environment.

- Biodiversity underpins agricultural ecosystem services by augmenting natural enemies to pest

Study design and data collection

- **Site/farm selection**:

-Altitude: Lower zone (< 1100m a.s.l); Middle zone (1100-1500m a.s.l); Upper zone (> 1500m a.s.l)

-Plant diversity, forestation

- **Data collection (May-October 2015)**

Collection of invertebrates	• **Five traps (20m apart), per site- margins and crops. Three pans (yellow, blue, white), water and a drop of detergent, 24 hrs, preserved in alcohol for identification** • **Collection on weekly basis and averaged per month.**
Collection of plants	• 2m sq. plots around the traps, observations of visits recorder for 20min and photos taken • Plants dried, identified and mounted
Temperature and rainfall monitoring	• average monthly rainfall and temperature recorded by tipping bucket rain gauge and thermometer respectively.

Insect capturing and plants identification

The invertebrates groups of interest

Beneficial insects	Group	Type of service
Ants	Hymenoptera: Formicidae	Predation, but possibly antagonistic
Predatory bugs	Hemiptera: Reduviidae	Predation
Bees	All Hymenoptera: Anthophila	Pollination
Butterflies	Lepidoptera:Rhopalocera	Pollination, but possibly larval pests
Hoverflies	Diptera: Syrphidae	Pollination (adults), predation (larvae)
Lacewings	All Neuroptera	Predation (larvae)
Lady beetles	Coleoptera: Coccinellidae	Predation (adults and larvae)
Long-legged flies	Diptera: Dolichopodidae	Predation
Net-winged beetles	Coleoptera: Lycidae	Predation
Robber flies	Diptera:Asilidae	Predation
Spiders	All Aranae	Predation
Tachinid flies	Diptera: Tachinidae	Parasitism
Wasps	All Hymenoptera that are not bees, ants or sawflies	Predation, parasitism, some pollination

Results

The identified invertebrates/insect groups

Pollinators

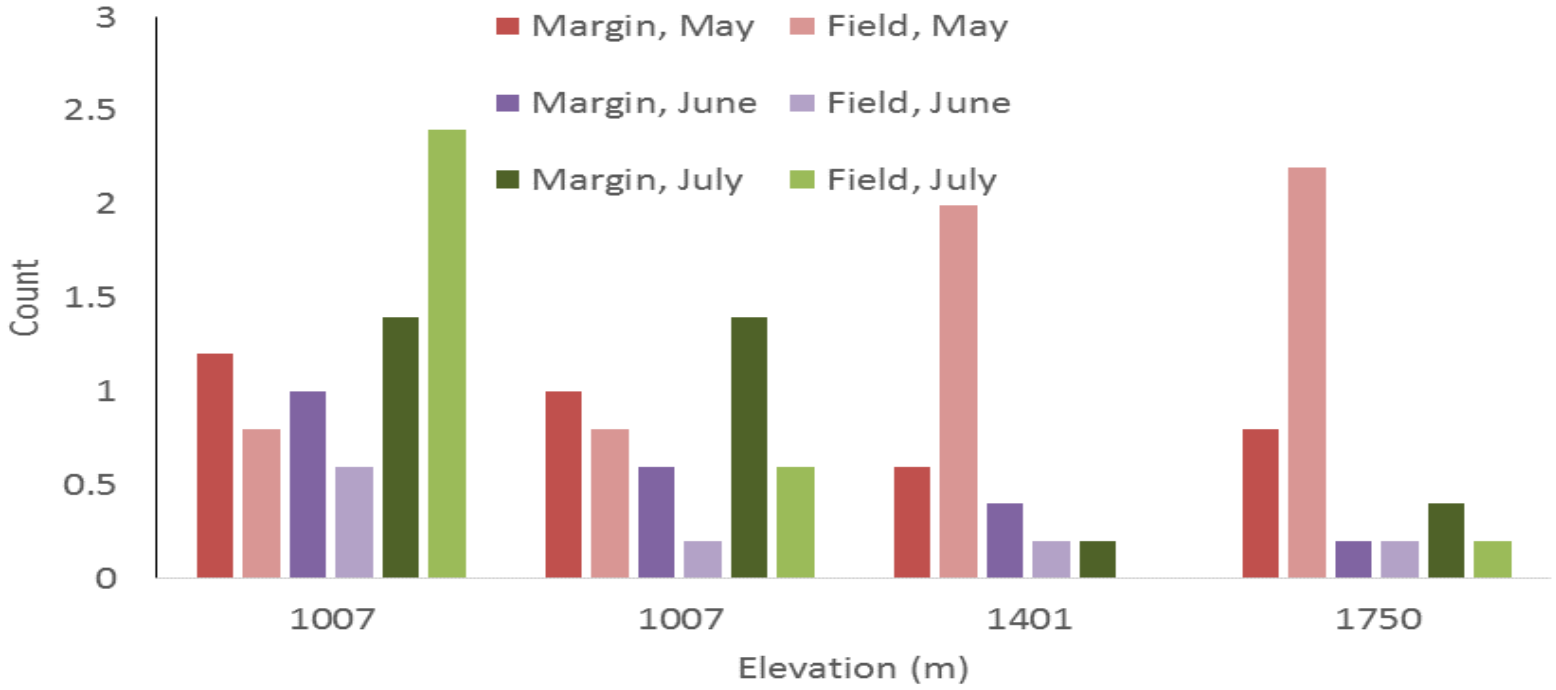
- Bees
- Butterflies

Predators and parasitoids

- Ants
- Predatory bugs
- Lacewings (larvae)
- Lady beetles
- Long-legged flies
- Net-winged beetles
- Robber flies
- Spiders
- Tachinid flies
- Wasps
- Hoverflies

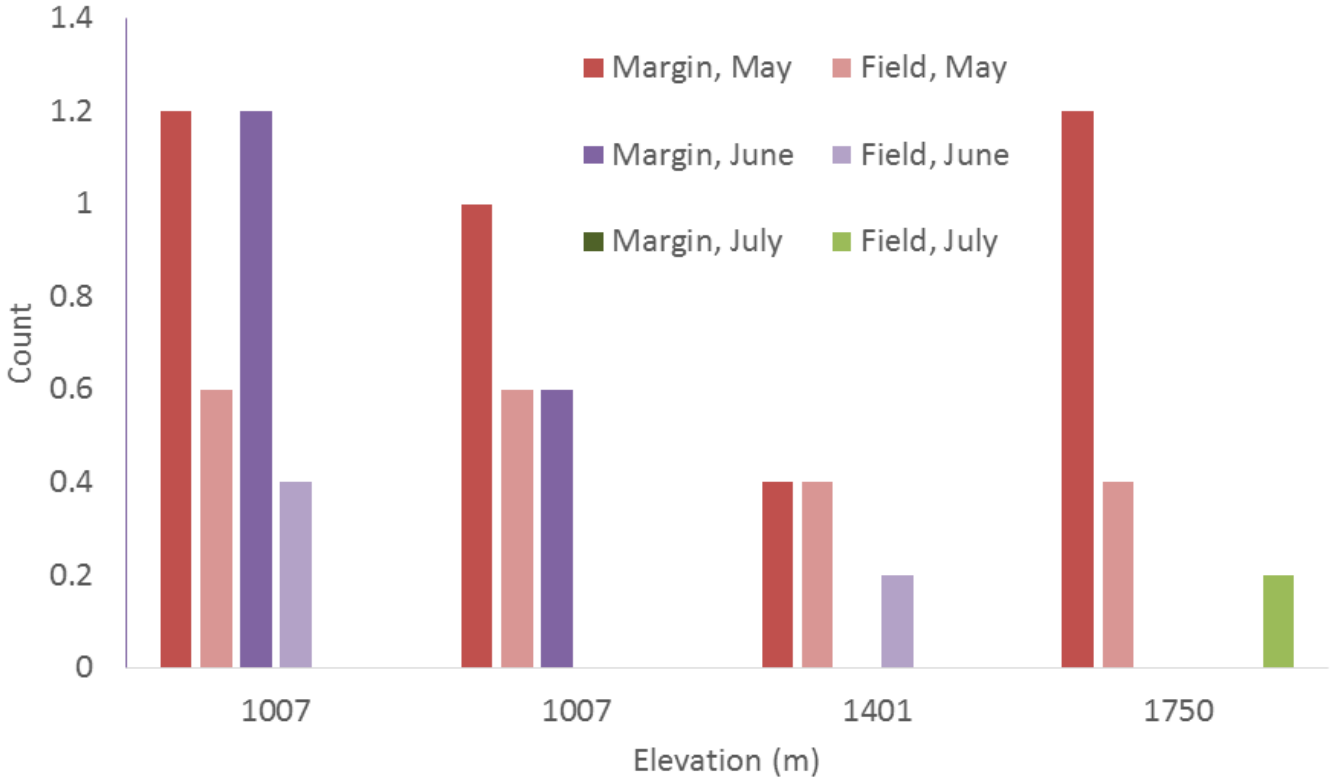
Abundance of functional groups were affected by elevation and time of the season

Abundance of bee at different elevations during the bean crop season.



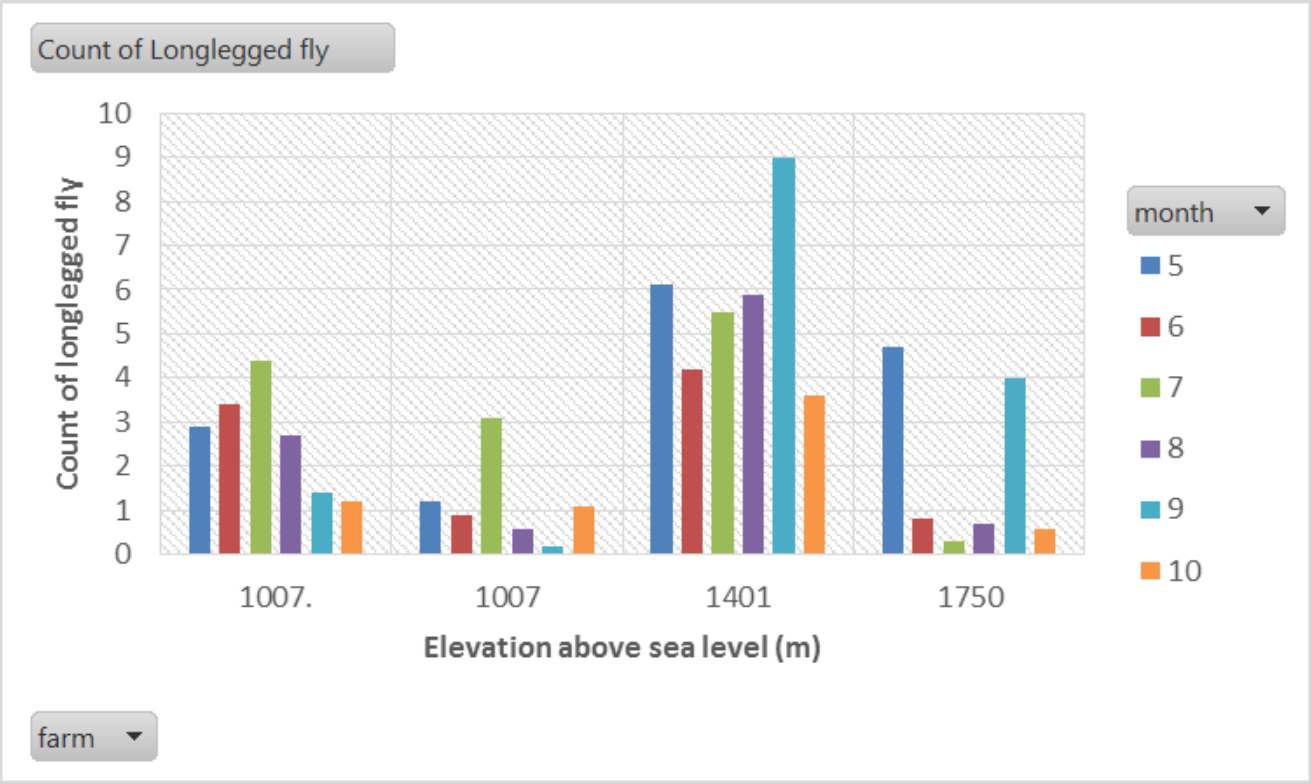
- The higher numbers of bees at low elevation (1007m.a.s.l) abundance and richness of plants in the field margins and in field crops.
- Low numbers of bees at middle and upper elevations- environmental conditions (lower temperatures and higher rainfall), destruction of the field margins. Bee density is influenced by habitats restored with floral resources (Heard *et al*. 2007)

Abundance of Syrphid fly at different elevations during the bean crop season



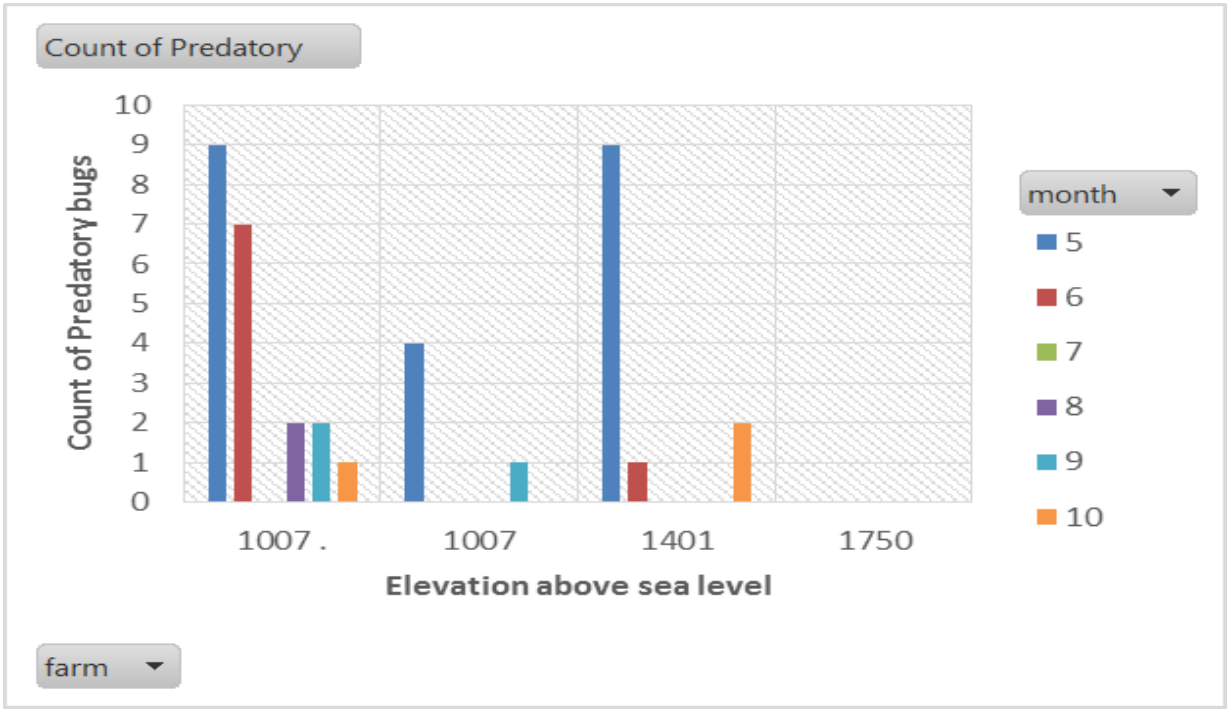
- Low numbers of adults Syrphidae in July indicate possibly low numbers of larvae during the growing period (April).
- Higher abundances May- abundant forage. The absence in July, August and September- destruction of the field margins. Floral resources promote populations of hoverflies in the field (Blaauw and Isaacs 2014)

Abundance of Dolichopodidae at different elevations throughout the sampling period



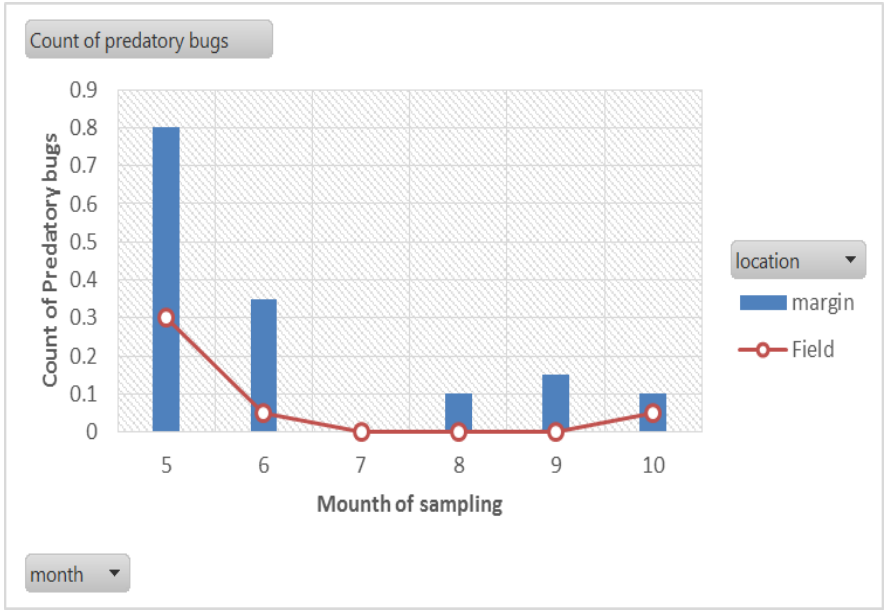
- High at the middle zone (1401m.a.s.l) due to *Colocasia esculenta plant* and moist environment with densely vegetation. The abundances of these flies are affected by the environmental determinants (Lambkin *et al* 2011)

Abundance of predatory bugs at different elevations throughout the sampling period

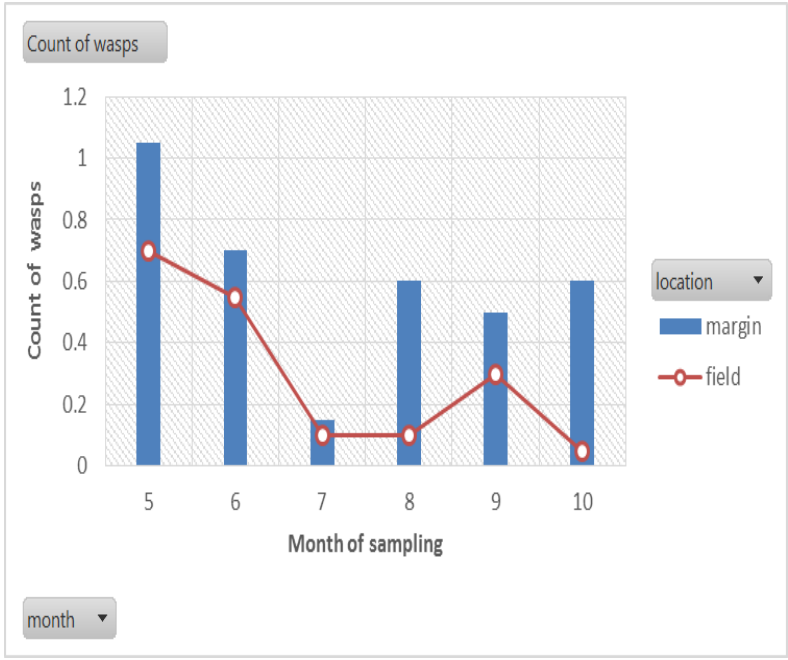


- Abundant at lower and middle elevation in May- availability of *P. imbricata* and prey e.g. pod borers which are abundant in low midland altitude (1103—1182m) (Nguluu *et al*. 2013). There is decreasing predation with increased altitude (Hodkinson 2005).
- Lack of the alternative plant resources at higher elevations. positive effects of surrounding for predators and pollinators (Rand and Tscharntke, 2007).

Abundance of wasps and predatory bugs at different locations in the field throughout the sampling period



Predatory bugs



Wasps

- Higher populations of key insect groups such as long legged flies, assassin bug and wasps observed in the field margins
- Higher populations of beneficial arthropods increased in habitats with higher plant diversity (Hillocks (1998) and Altieri 2002).

Common plants associated with beneficial insects

Insect / Plant	Bees	Hoverflies	Butterflies	Wasps	Assassin bugs	Spiders	Tachinidae	Lady beetles	Dolicho podidae
Ageratum conyzoides	**	**	**						
Conyza bonariensis	**	**	**						
Stachytarpheta cayennensis	**	**	**						
Ocimum bassilicum	**	**	**						
Bidens pilosa	**	**	**	*					
Galinsoga parviflora	**	**	**	*					
Phaulopsis imbricata					**				
Euphorbia heterophylla				**					
Achyranthes aspera	**								
Justicia bracteata	*		*	*					
Colocasisa esculenta									**
Commelinna benghalensis	**					*	*	*	

**Frequent visits,* Occasional visits

Some observed Plants association with beneficial insects

The *Euphorbia heterophylla* associated with the paper wasp (natural enemy and pollinator)

The *Colocasia esculenta* association with long-legged fly (predator as adult)

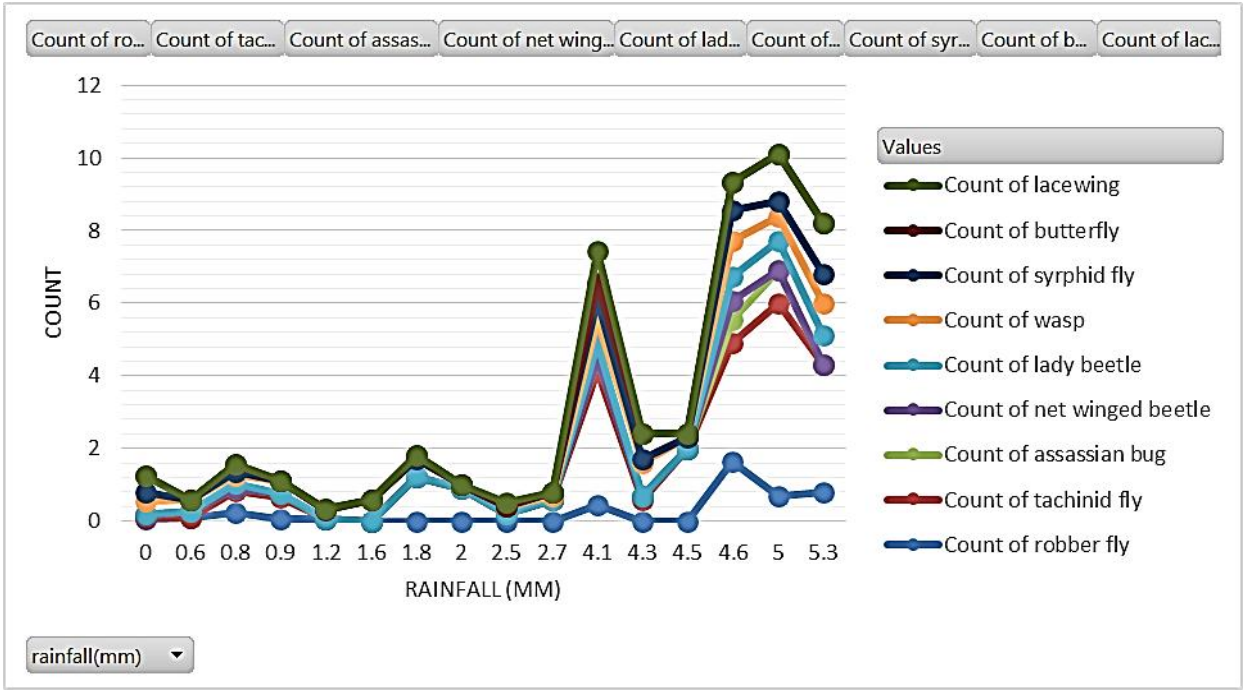
Plants association with hover fly (pollinator as mature insect, predator as larvae).

Bidens pilosa

Ageratum conyzoides

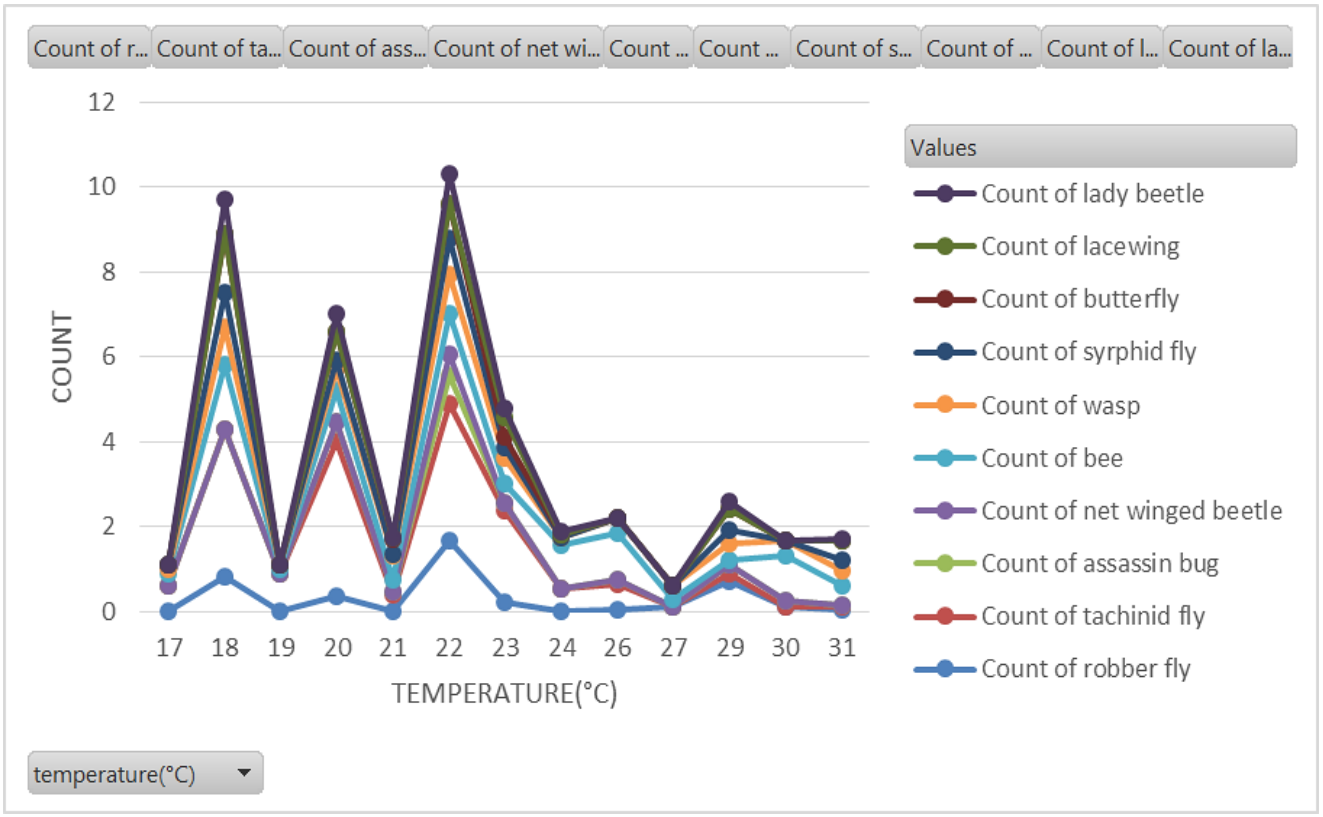
Functional groups were significantly affected by temperature and rainfall

Effects of rainfall on different functional groups of agriculturally-important in this study system

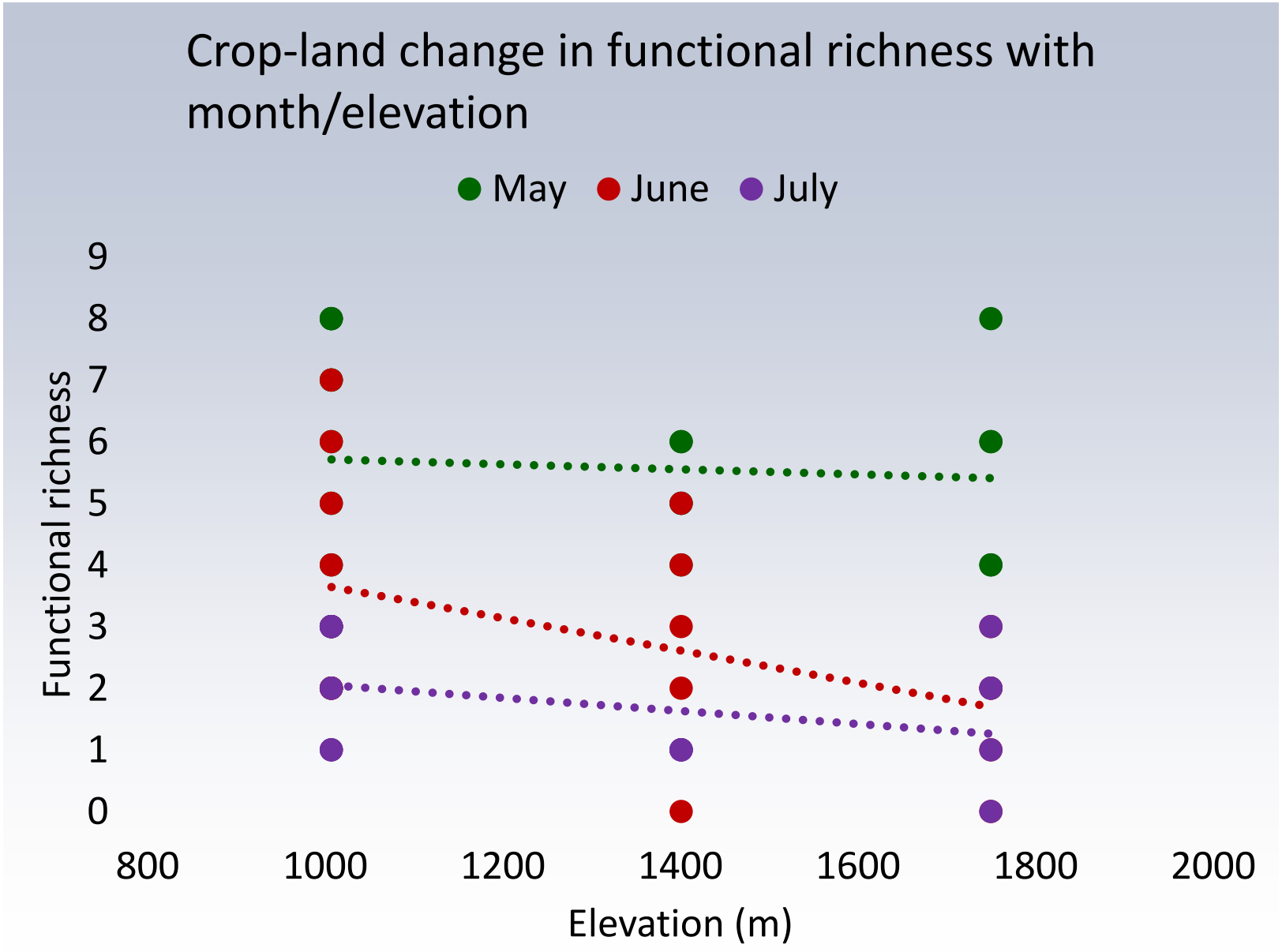


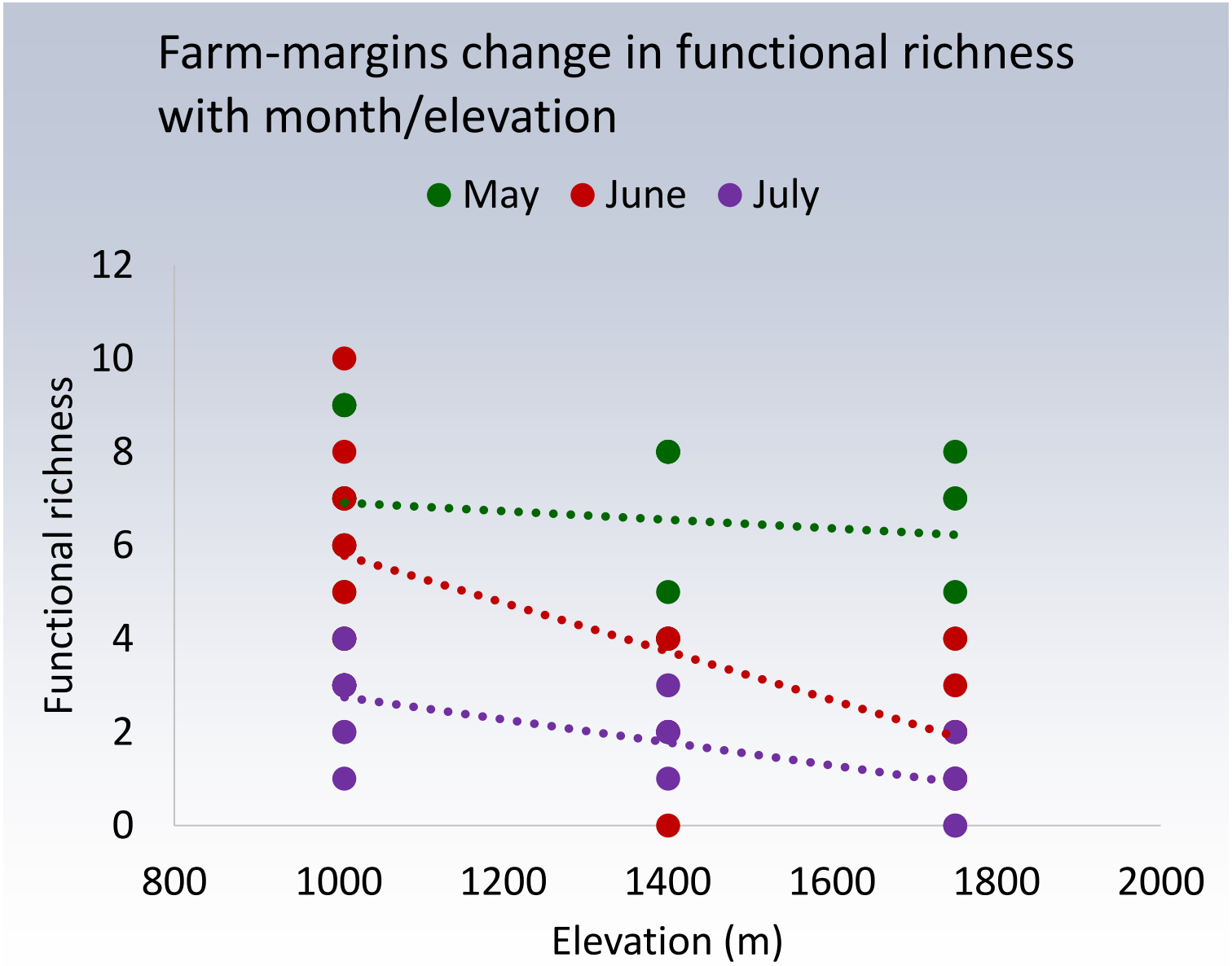
- Wasps, robber flies, tachinid flies, hoverflies, lacewings, lady beetles and assassin bugs favoured by higher (monthly) rainfalls above 4.5mm.
- Environmental conditions have impacts on the biological traits of natural enemies (Fand & Suroshe 2015)

Effects of temperature on different functional groups of agriculturally-important in this study system



- Lacewings, lady beetles, robber flies, tachinid flies, hoverflies, bees and assassin bugs abundant at temperatures lower than 23°C (Sengonca 2003)


Crop-land change in functional richness with month/elevation
May
June
July
Functional richness
9
8
7
6
5
4
3
2
1
0
800
1000
1200
1400
1600
1800
2000
Elevation (m)


Farm-margins change in functional richness with month/elevation
May
June
July
Functional richness
12
10
8
6
4
2
0
800
1000
1200
1400
1600
1800
2000
Elevation (m)

Conclusion

- Sites showed variability, both between sites, in terms of the abundance and richness of invertebrates present, but also at the same site but at different times of year/season .
- The aphid predators (long-legged flies) and lacewings were particularly sensitive to elevation.
- Higher populations of key insect groups in the field margins than in the crop itself.
- Some key field margin plant species were found associated with beneficial insects.

Acknowledgement

COULD FIELD MARGIN PLANTS HOLD THE SECRET TO SAVING CROPS FROM PESTS?

Researchers build on age-old practices to reduce food loss in Africa