

African edible-insects: diversity and pathway to food and nutritional security

Segenet Kelemu, PhD

Director General, icipe



icipe: General facts



A centre of excellence in Africa—for research and capacity building in insect science and its applications

An *intergovernmental organization* — charter signed by 13 countries worldwide

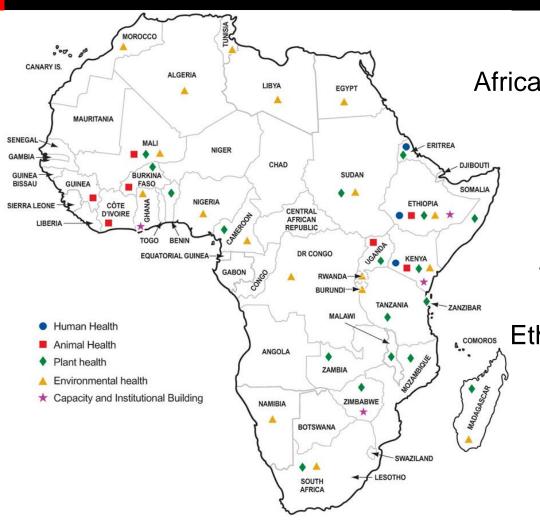


≈ 450 staff total, 50–70 MSc, PhD students in residence Many contracted workers

An organization with a *unique*history — 40+ years old,
genesis in Africa

General facts – where we work





Africa focused- currently activities in 30 countries

Global collaborative work

International HQ in Nairobi

Several field stations across Kenya & country offices in Ethiopia and Uganda (planned for Rwanda,and DRC)

How we work





4-Hs paradigm

R&D on human, animal, plant & environmental health, and capacity building

 Common denominator insects/ arthropods

Capacity Building Program =

- > ARPPIS- 257
- ➤ DRIP- 408
- ➤ Short-term internships- > 500
- ➤ Group Training- >1000
- ➤ Postdoctoral fellows- 40
- ➤ Institutional Building- HES, NARS



General facts – funding





Core-funding: mainly from the Governments of Sweden, Switzerland, UK, Germany, & Kenya



Project funding: EU, Biovision, national & international donor agencies, Foundations, UN organizations, World Bank and others.

Why consider insects for food & feed?







Cirina forda

- By 2050, global food production must double to feed an estimated 9 billion population
- Addressing this requires a clear sense of longterm challenges and possibilities
- Insects as food and feed have an important role to play in assuring food security (van Huis, 2013):
 - ✓ Over 2000 species are consumed
 - ✓ Nutrition contents are comparable to meat and fish
 - √ Feed cost & advantages with conversion ratio
 - ✓ GHG emissions
 - ✓ Zoonosis
 - ✓ Water use efficiency
 - √ Organic waste conversion

Insects & Other uses

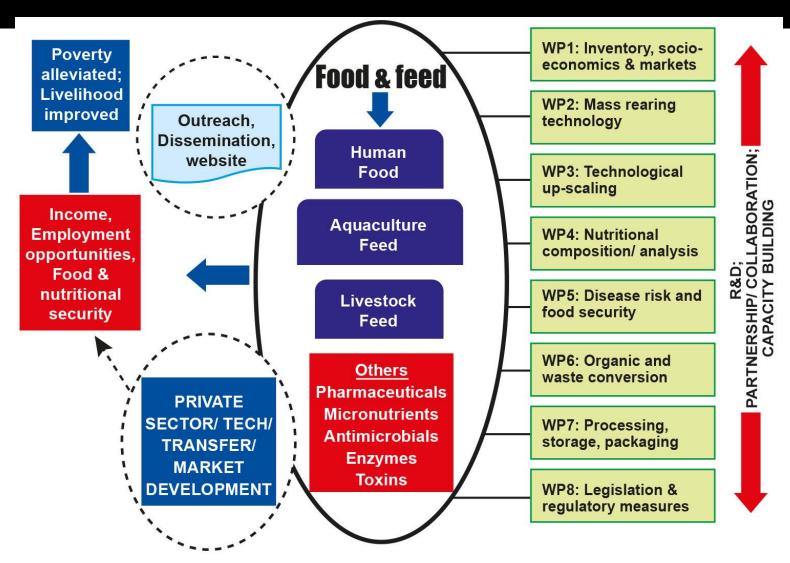




- Antimicrobials Antimicrobial peptides (AMPs) from insects as alternative agents for fighting human-pathogenic microorganisms
- Industrial enzymes Demand for industrial enzymes for the production of biofuels and fine chemicals
- Chitin enhancing effect on the functioning of the immune system of different organisms
- Biosurgery (maggot therapy) New species & molecular basis for therapy is unclear and must be unraveled
- Bioactive metabolites with medicinal properties (application of analytical chemistry to identify potent compound)
- Others: aircraft designs; sniffing capacity for drugs, mines, several others

icipe's INSEFF Conceptual Framework

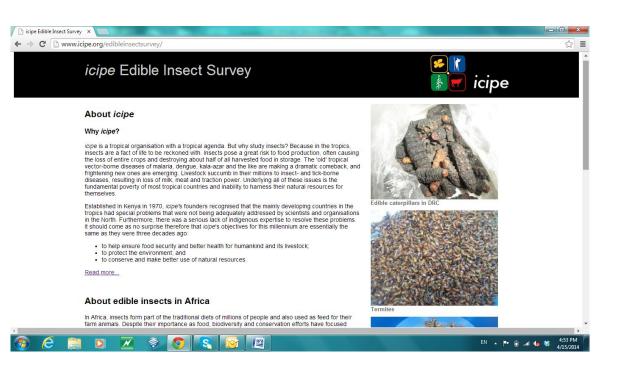




Broad-based scientific effort need to advance and promote insects for food, feed and other uses

Inventory of African edible insects





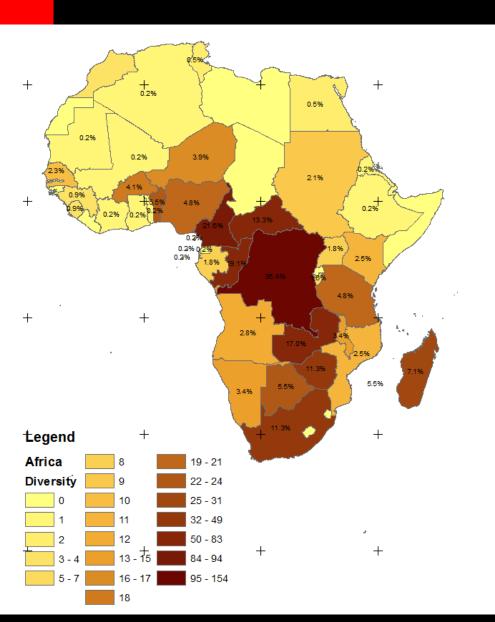
- >300 respondents so far
- From over 21 different countries (16 African)
- >91% of respondents are aware of edible insects

Survey objectives

- Update available information on edible insects in Africa
- Establish the hotspots of consumption in Africa
- Establish awareness of the importance of edible insects
- Document indigenous practices employed for harvesting
- Assess the role of gender and children in edible insect harvesting

Inventory of African edible insects

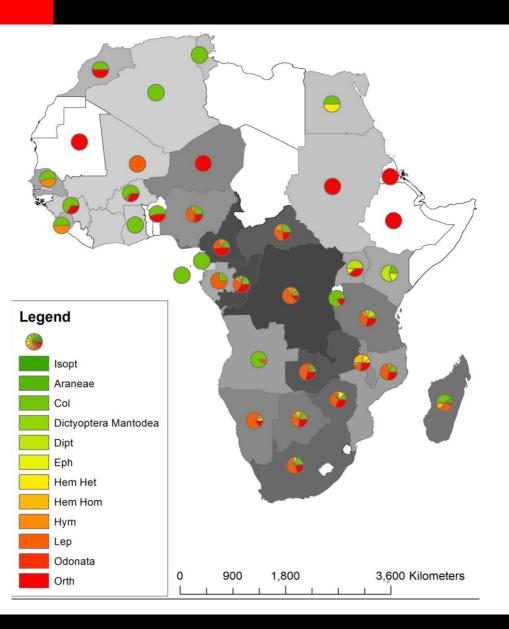




- Approximately 500 species of insects are eaten across Africa (More than 1/3 of the global list)
- Central and Southern Africa are hot spots of edible insects
- There is still general dearth of information on edible insects from North Africa, parts of West Africa and the Horn of Africa
- Paradoxically, food security situation in these countries remain precarious

Inventory of African edible insects

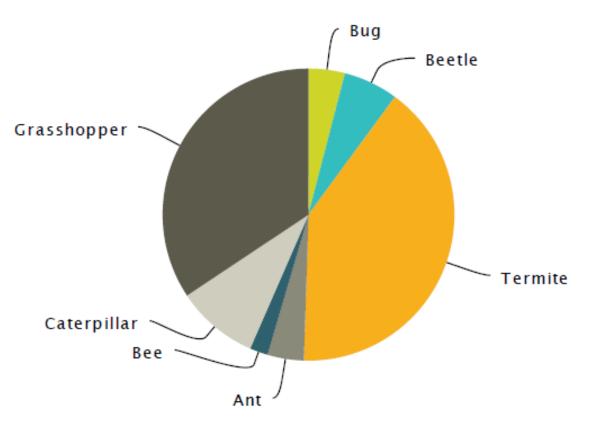




- 12 groups of insects are consumed in Africa
- High numbers of species are consumed in Central and Southern African countries compared to West and Eastern Africa
- Dominant groups consumed:
 - ✓ Lepidopterans
 - ✓ Orthopterans
 - ✓ Coleopterans
 - √ Isopterans
 - √ Hymenopterans

Awareness among respondents that insects are edible

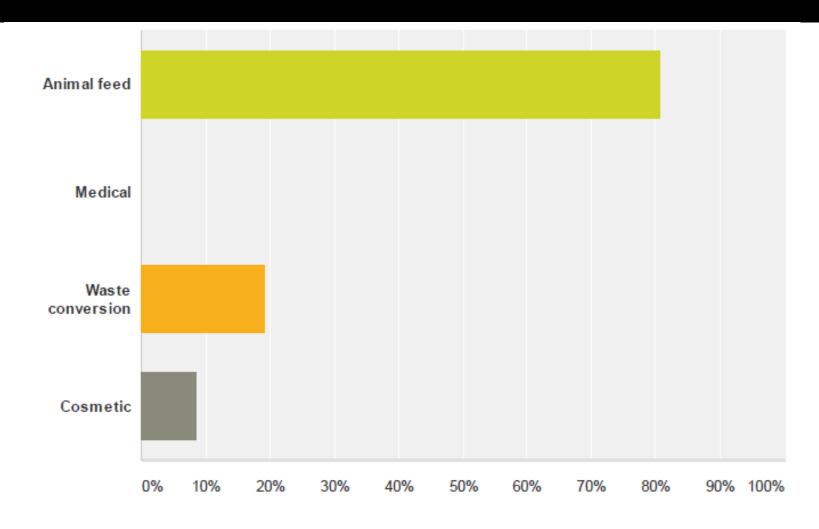




- □41% respondents
- ☐ This highlights the need to create awareness among all stakeholders
- ☐ Greater awareness on grasshopper and termites as edible insects

Awareness beyond edible

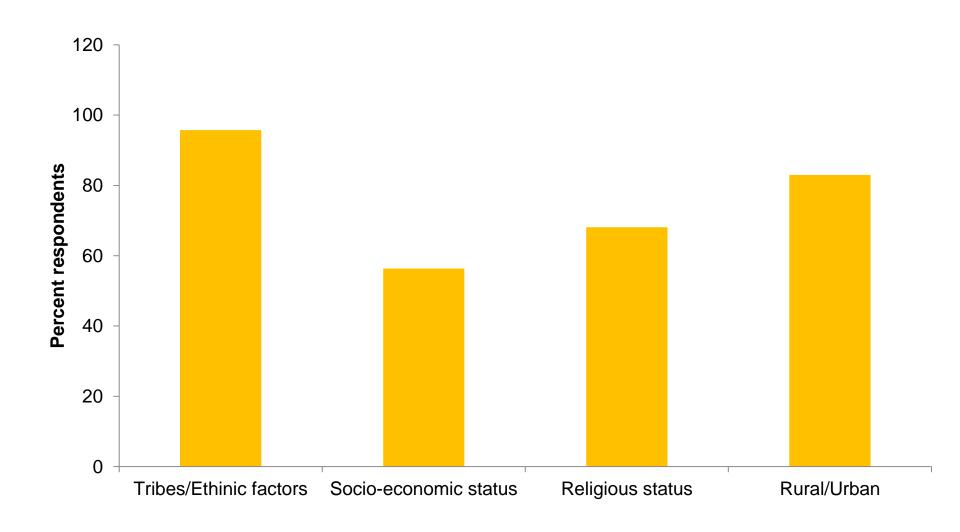




Interestingly – zero are aware of the use of insects in Medicine

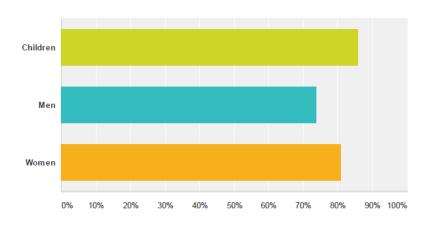
Socio-cultural factors found to influence edible insects





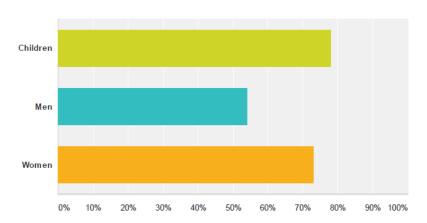
Consumption and collection





Not much difference among consumers

Percentage of respondents

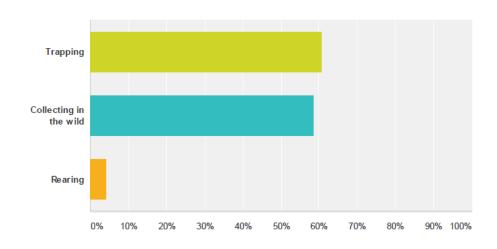


Women and children play a key role in collection of insects

Percentage of respondents

Production and marketing

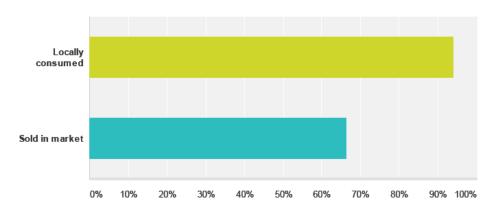




Largely by trapping and collection in the wild

Need to develop, mass rearing and science based efficient collection/trapping

Percentage of respondents



Largely consumed locally highlighting the potential to impact food security

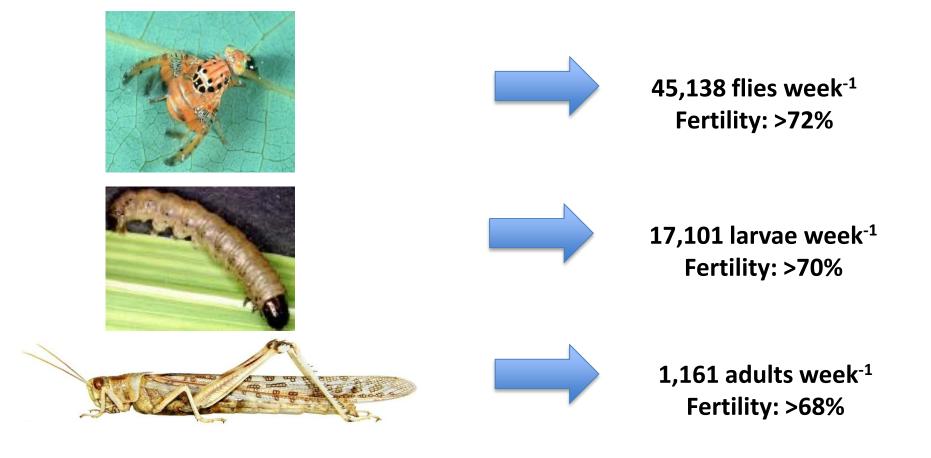
Potential to be sold in markets is also promising

Percentage of respondents

Mass rearing capacity at icipe



- > 40 year experience in arthropod mass rearing
- > 100 different arthropods species have been reared at the icipe ARQU



Mass rearing capacity at icipe





Rearing techniques developed and adapted for laboratory, large scale enterprises as well as small scale farming condition

 Quality control parameters and containment constitute integral parts of rearing techniques developed

21

Mass Rearing and Quality Control Parameters for Tephritid Fruit Flies of Economic Importance in Africa

> Sunday Ekesi and Samira A. Mohamed International Centre of Insect Physiology and Ecology (ICIPE), PO Box 30772, Nairobi, Kenya

Ekesi, S. & Mohamed, S.A. (2011) Mass rearing and quality control parameters for Tephritid fruit flies of economic importance in Africa. In: *Wide Spectra of Quality Control*. InTech Publishing, Rijeka, Croatia. Pp.387-410. ISBN 978-953-307-683-6



1. Introduction

Tephritid fruit flies are recognized worldwide as the most important threat to horticulture (Allwood and Drew, 1997; Barnes, 2004; Ekesi and Billah, 2007). Sub-Saharan Africa (SSA) is the aboriginal home to 915 fruit fly species from 148 genera, out of which 299 species develop in either wild or cultivated fruit. They belong mainly to four genera: Bactrocera, Ceratitis, Dacus, and Trintithrum (White and Elson-Harris, 1992). Most of the fruit fly species are highly polyphagous attacking several important fruits and vegetables including mango,

Organic waste management





- Substrate use in insect mass rearing can help in converting organic wastes into animal biomass for feed
- Insects like black soldier flies (Hermetia illucens) can covert toxic municipal, kitchen and human waste into safe fertilizers

Harvesting: traditional knowledge



 Various edible insects are traditionally harvested during natural swarming (e.g. grasshoppers, locusts etc): technique is unreliable



Source: www.getintravel.com

- Others (e.g. Palm weevils -Rhynchophorus phoenicis, R. ferrugineus etc) require injuring plants to release kairomones: unsustainable
- Farmers harvest termites by playing special drums with specific sounds: for how long?

 Farmers also rely sometime on sound made by various insects (crickets, beetles, longhorn etc) to tract and harvest them:
 dependent on nature

Harvesting: improved trapping







- The long experience of *icipe* and partners in development of efficient trapping techniques will be handy for harvesting edible insects
- Visual and olfactory cues developed for capture of fruit flies, tsetse flies etc
- Increased use of traps for capturing plants and animal pests and their use for feed provide a holistic approach to improving agricultural productivity

Chemistry – Encosternum delegorguiei 🕌 icipe







- Consumed in Zimbabwe, South Africa and Laos
- Nutritional benefits well known (Teffo et al. 2007. South African Journal of Science Vol 103 (11-12)
- Potential Health benefits and risk of consumption unknown
 - Focus of Robert Musundire's (bottom left) study

Health benefits – Encosternum delegorguiei



 Source of flavonoids: likely host plant of the stink bug

- Roberts' findings analyzing uncooked and cooked stink bug:
- Rich source of anti-oxidants in both sources (scavengers of free radicals from the body; anti-skin cancer and anti-inflammatory agents)
- An example of anti-oxidant identified is the flavonoid **Luteolin**.
- Found in a wide range of spices and vegetables
- Other flavonoids identified in uncooked and cooked stink bug include rutin and quercitin

Health benefits – Encosternum delegorguiei





- Good source of fatty acids including Essential Fatty Acids (i.e. omega-3 and omega-6 fatty acids)
- Critical components required by human body for many functions but body cannot synthesize them (found in other foods- picture left)

Source: www.okdietas.com





Processing of the edible stink bugs

Storage of the bugs



Chemical composition (%DM) of Edible Stink Bugs

Parameter	Processed Bugs	Unprocessed Bugs	Common Beans	meat
Dry Matter	94.9	91.2	-	-
Ash	1.8	1.6	2.7 - 4.5	-
Organic matter	98.2	98.4	95.5 - 97.3	-
Crude fat	57.7	62.4	0.9-4.4	10.8 -12.7
Crude protein	37.7	33.2	22.5-28.0	28.0 - 36.0
Neutral detergent fibre	33.5	37.8	21.0-31.9	-
Acid detergent fibre	19.0	17.2	17.0-22.8	-

Vitamin composition (mg/kg)of Edible Stink Bugs

Parameter	Processed Bugs	Unprocessed Bugs	Beef
Vitamin A	7.77	1.85	<0.5
Vitamin C	0.03	0.03	

Processing and preservation

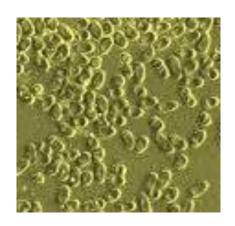




- Safety issues must be identified and mitigated
- Shelf life can be extended by refrigeration, canning
- Sun-drying and packaging in sacks
- Eviscerating (degutting) and drying
- Baked, boiled, steamed, and processed into crackers, muffins, sausages, and meat loaf
- Processing and nutritional composition studies required
- Processing vs aflatoxin contamination

Food safety and risks





Pseudomonas aeruginosa



Streptococcus aureus

- Safety issues regarding consumers and animal health must be identified and mitigated, e.g.,
 - microbial
 - chemical
 - toxicological, and
 - allergenic risks
- Diagnostic tools for routine detection and quantification of pathogens
- Compositional analysis for levels of allergens and toxins
- Index of safety levels for toxins and allergens in foods and feeds
- Risks of escape and containment measures

Policy & regulations



- Specific legal status on the use of insect for food and feed does not exist in many countries
- Insects are rather regarded as impurities
- Clarify the regulatory status of insect as food and feed ingredient and develop recommendations to guide the development of standards
- Organize stakeholder workshops to facilitate implementation of the use of insects as food and feed ingredients in national and Codex Alimentarius standards
- Organize workshops and trainings to raise the profile of insect as feed ingredient
- Regulations governing outbreaks of potential diseases harmful to human, animals
- Explore the concept of novel foods to develop standards

Capacity building, partnerships, outreach,





- Facilitate and support participatory development and dissemination of technologies
- Hands-on ToT & producers
- Workshops/seminars
- Printed & electronic guides (field guides, posters, leaflets, newspapers, websites)
- Radio & TV programs
- Exchange visits, agric shows, field demonstrations
- Partnerships: GREEiNSECT, WinFood, FAO, WAU
- Private sector (AgriProtein, Enviroflight, Synargy etc)

Summary and conclusions



- Insects have always been a part of human diets and in Africa >500 species are consumed
- Utilization must be promoted in the face of changing consumption patterns, impacts of climate change and the growing scarcity of water and land
- Although insect for food and feed is a sector at its infancy, it clearly can contribute to food security
- Research in needed in the fields of:
 - ✓ Mass rearing techniques
 - ✓ Nutrition
 - ✓ Disease risk and food safety
 - ✓ Processing, storage and packaging
 - ✓ Marketing
 - ✓ Legislation and regulatory measures
- Aside of from their role in contributing to food security, research should also take advantage of other uses as exemplified in the presentation

- African edible insects inventory completed and paper in press;
- Approx. USD 3.0 million raised;
- Research strategy and framework developed;
- Private sector and research partnerships established; and
- Two keynote speeches and several posters presented at international conferences on edible insects.

Private sector partnerships for impact



- AgriProtein, SA Production and commercializing nsects as feed (Southern Africa)
- EnviroFlight, USA Production and commercializing insects as feed (Eastern Africa)
- Sanergy Ltd Interested in insects for organic waste conversion

Changing perceptions and image



- Public perception and acceptance
- Insects for food and feed should not be promoted as just a solution for the poor or for Africa, Asia and LA
- Demonstration of the nutritional and health value can help change perception
- Involvement of top restaurants and chefs (e.g. French cuisine)
- Change of the image of insects themselves (e.g bees have a positive image)
- No technology or product is a silver bullet for food security

thank you









Insekter som produktionsdjur i lantbruket -den nya flugan

13.50 Fluglarvskompostering löser både avfalls-och foder problematiken – Björn Vinnerås, Docent, SLU

14.20 Kaffe / Coffee

14.45 Växtnäringskretslopp utan risk för smitta eller läkemedels rester – Cecilia Lalander, Forskare, SLU







Fluglarvskompostering löser både avfalls- och foderproblematiken

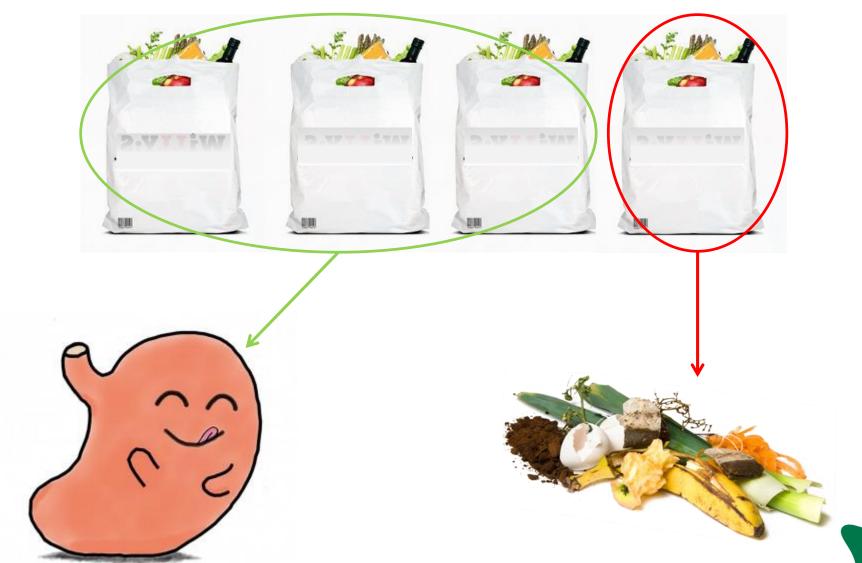
Björn Vinnerås Institutionen för Energi & Teknik





Avfallshantering idag

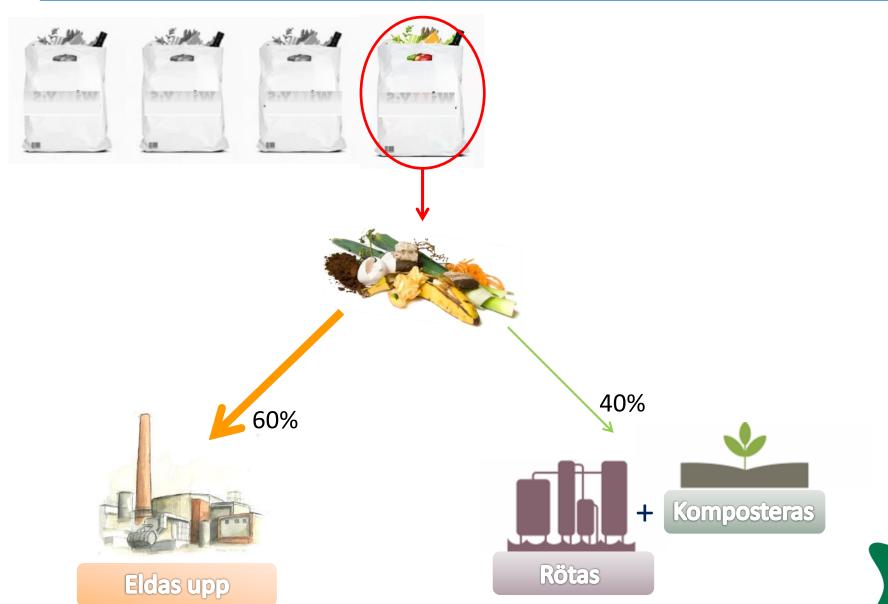






Avfallshantering idag



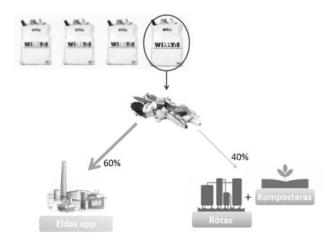




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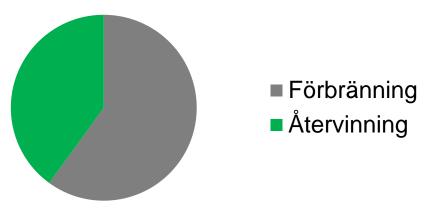


60% eldas upp,40% komposteras/rötas

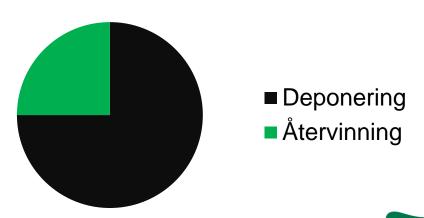


Globalt deponeras 75%

Avfall i Sverige



Globalt





Gödselhantering



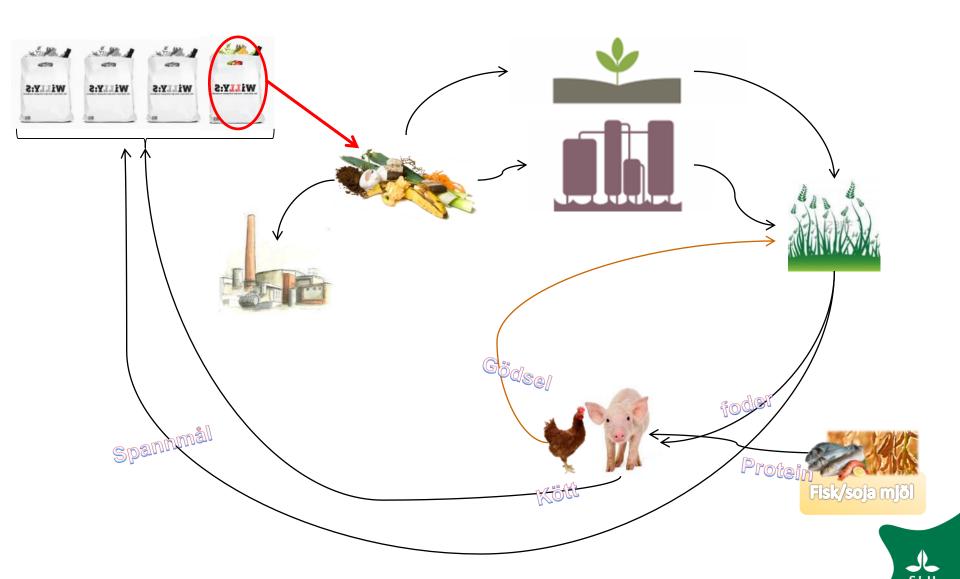
- Större gårdar
- Markkrav för gödsel
- 60-80km till "sista fältet" inte ovanligt
- Övergödsling på nära fält
- Gödselkoncentrering?





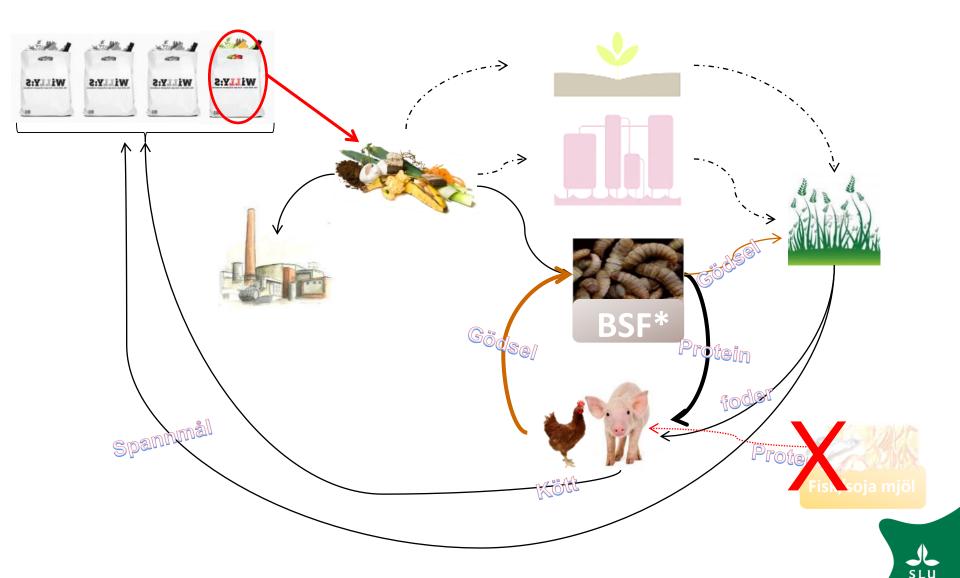
Traditionell återvinning





Vår genväg i kretsloppet





Fluglarvskompostering









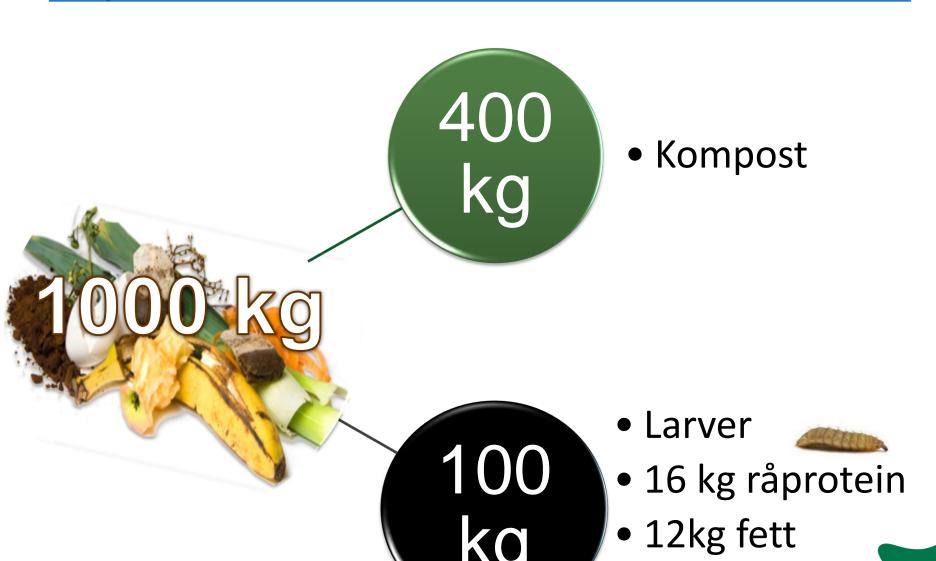
5,000 Larvae vs 2 Fish



Fluglarvskompost



• 500 Kr



SLU

Självskördande larver

- Lämnar materialet för att förpuppas
- Samlas då lätt in
- Torkas & Mals
- Protein & Fettdel i foderblandning
 - Fisk
 - Fågel
 - Gris
 - Husdjur (Katt/Hund)







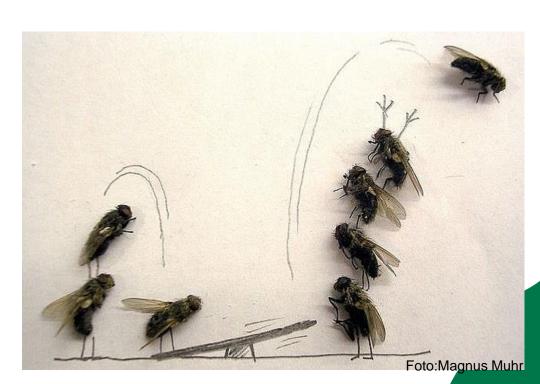




Utmaningar



- Flugor är produktionsdjur
 - ABP-förordningen (EU-nivå)
 - Diskussion om lagändring pågår
- Andra utmaningar
 - Acceptans
 - Konkurrerar med biogas
 - Föroreningar
 - Organiska
 - Mikrobiella



Två flugor i en smäll

80000

- Miljövänlig produktion
 - Avfallshantering
 - Mindre förbrukning av råvaror
 - Lokal foderproduktion
- Miljövänliga produkter
 - Motverkar
 - Överfiskning
 - Minskad användning av sojaprotein
 - Andra potentiella produkter
 - Plast / Biodisel / Vaxer

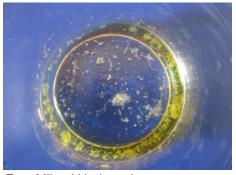
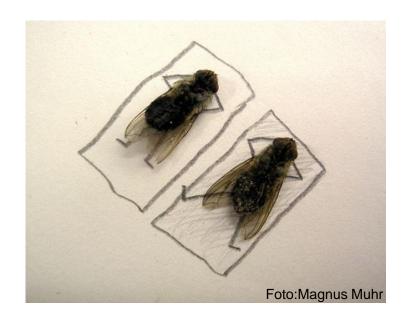


Foto:Mikael Hedenqvist





Framtida implementation



- Stor global potential
- Värdet i 1 ton avfall
 - 500kr avgift
 - 200kr värde på kompost
 - 500kr värde på proteinprodukt

1% av marknaden, ökat värde för avfallet visas nedan

Region	Avfallsvol	Larv-	Protein-	Fett-	Totalt	Antal
	(ton)	mtrl	värde	värde	värde	anlägg
		(Mton)	(MSEK)	(MSEK)	(MSEK)	
Sverige	6 840	0,27	2,1	0,7	2,8	1
EU	370 000 000	15 600	320 000	210 000	530 000	500
Afrika	740 000 000	31 200	640 000	420 000	1 060 000	5 000





Växtnäringskretslopp utan risk för smitta eller läkemedelsrester

Cecilia Lalander

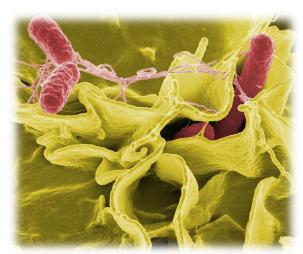
Forskare Institutionen för energi och teknik Sveriges lantbruksuniversitet



Undersökta mikroorganismer

Salmonella spp.

- Zoonotisk bakterie: infekterar djur och människor
- Orsakar diarre
- Stor påverkan på lantbrukssystem



Rocky Mountain Laboratories, NIAID, NIH

Spolmaskägg (Ascaris spp.)

- Parasitär mask
- Delvis zoonotisk
- Äggen mycket behandlingståliga





CDC Division of Parasitic Diseases

Undersökta processystem

Satssystem

- Alla larver lika gamla
- Cykel tar slut då larverna utvecklas till prepuppor



Kontinuerligt system

- Larver av olika åldrar
- Larvkompost sker i samklang med väl utvecklad mikrobiell flora





Satssystem – överlevnad i material

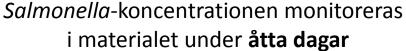
Material av hög koncentration av

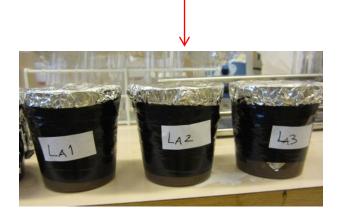
Salmonella

spolmasksägg

tillsättes första dagen

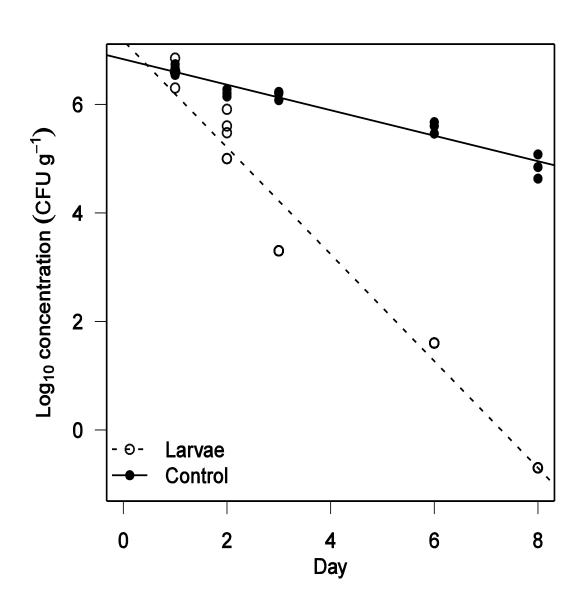






Koncentrationen och viabiliteten av spolmasksägg analyseras efter tre dagar

Inaktivering Salmonella





Inaktivering spolmasksägg

	Larval-treated faeces	Control
Percentage viability (\pm SE) 3 day exp. Estimated concentration (ova g ⁻¹ ww)	94 ± 0.6 320	88 ± 1.4 150

ingen inaktivering av spolmasksägg i satsvis fluglarvskompostering



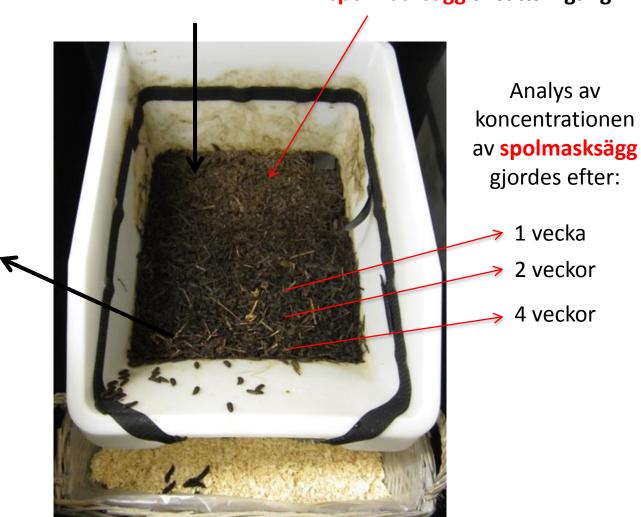
Kontinuerligt system

Material med hög *Salmonella* koncentration tillsätts **3 gånger i veckan**

Material med hög koncentration av spolmasksägg tillsätts 1 gång

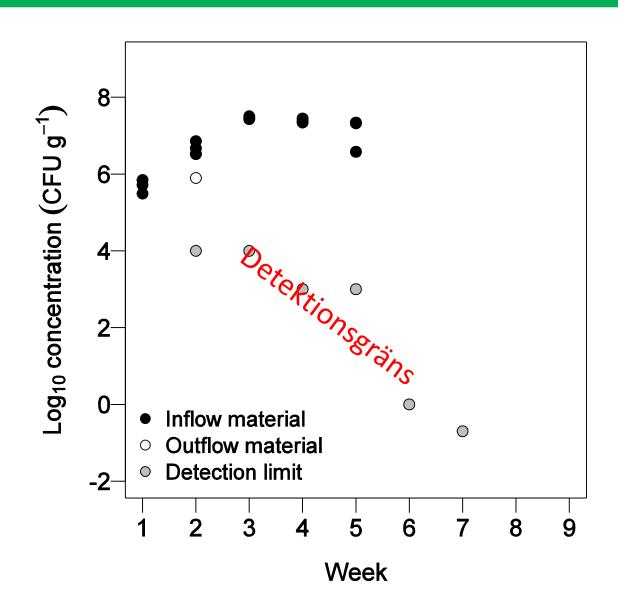
Analys av

Salmonellakoncentrationen
gjordes varje
vecka i nio veckor





Inaktivering av Salmonella





Inaktivering av spolmasksägg

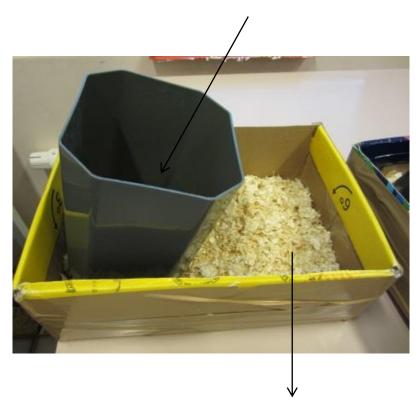
	Time since inoculation (days)			
	0	7	14	28
Concentration (eggs g^{-1})		72.62 ± 11.71	23.04 ± 8.93	84.55 ± 68.8
Viability (%)	90.33	82.86 ± 4.3	75 ± 1.56	78.62 ± 6.7

ingen inaktivering av spolmasksägg i kontinuerlig fluglarvskompostering



Hygien i prepuppor

Material av hög *Salmonella*-koncentration tillsätts vid alla matningstillfällen



Salmonella-koncentrationen i prepupporna analyseras



Hygienisk kvalitet av prepuppa

Salmonella

	Koncentration (CFU g ⁻¹)
Ingående material	10 ⁵ - <1
Prepuppans mage	<0.5

Entomological Research 42 (2012) 219–226

RESEARCH PAPER

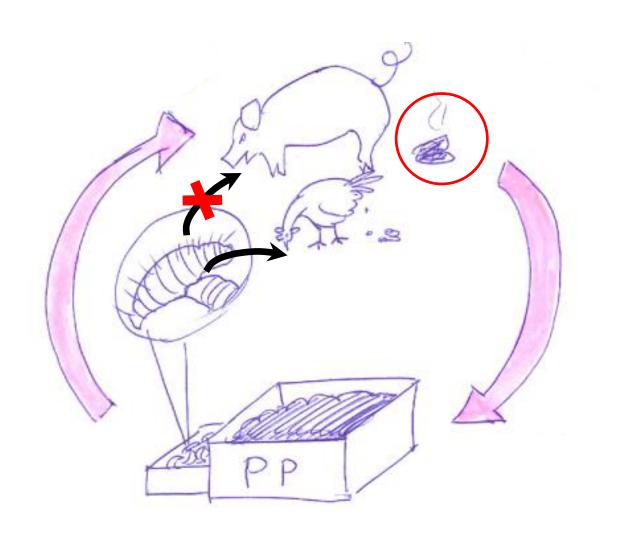
Antibacterial effect of extracts of *Hermetia illucens* (Diptera: Stratiomyidae) larvae against Gram-negative bacteria

Won-Hyung CHOI, Ji-Hye YUN, Jong-Phil CHU and Ki-Back CHU

Department of Medical Zoology, Kyung Hee University School of Medicine, Seoul, Republic of Korea

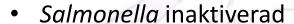


Hygienisk säkerhet av systemet

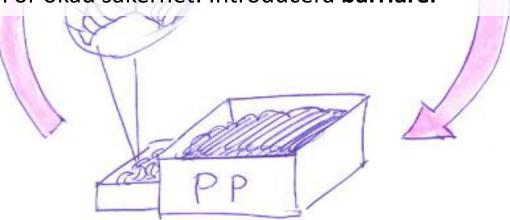




Hygienisk säkerhet av systemet



- minskad risk för smittspridning mellan djur och människa och mellan olika djur
- För ökad säkerhet: Introducera barriärer





Nedbrytning av läkemedelsrester

• Experimentet utfört i *satssystem* under en larvlivsscykel

 Undersökta substanser: roxitromycin, trimetoprim, karbamazepin, diklofenak

 I genomsnitt bröts substanserna ner >99% under komposteringen



Sammanfattning

 Fluglarvskompostering är en effektiv komposteringsmetod för organiska restprodukter med stor Salmonella inaktivering och hög nedbryning av läkemedelsrester

 Hygienisk säkerhet av systemet kan ökas genom efterbehandling av material/prepuppor eller genom att introducera barriärer

 Eventuell efterbehandling förenklas i och med den enorma volymminskningen



Över till larvena igen

eawag

4,500 Larvae
vs
1 Hamburger









Insekter som produktionsdjur i lantbruket -den nya flugan

15.50 Potential för foderproduktion –Diskussion

- Helena Wall, prof. i fjäderfäproduktion, SLU
- Zofia Kurowska, statsinspektör, Livsmedelsverket
- Sofia Boqvist , universitetslektor, SLU
- Hilda Runsten, expert Miljö och Klimat ;LRF
- Magdalena Presto Agr. Dr. och foderkonsult
- Tord Strömberg, Agronom, ansvarig uppfödning/ foder Bjärefågel

16.00 Avslutning



