Soil Association

Soil Association evidence on the Environmental Audit Committee Inquiry into Insects and Insecticides

Summary

- The UK Government is ignoring the strong and quickly growing body of scientific evidence which points to the damaging impact of neonicotinoid pesticides on pollinating insects, including bumblebees and honey bees (see Annex 1).

- Scientists have established that very, very low doses of neonicotinoids, well below what European governments consider a 'safe' level of toxic chemical, can disrupt bee behaviour in ways likely to contribute to the collapse in numbers of honeybees, bumble bees and other pollinating insects.

- Defra has made commitments to put in place new research to explore further the impacts of neonicotinoids on bumblebees and have acknowledged that the risks of pesticides to bees needs to be updated, but these plans ignore the weight of existing evidence, and will delay the action that the Government should take now.

- The European Food Standards Agency has admitted that neonicotinoid and other systemic insecticides have not been properly evaluated ever since their introduction and use of some neonicotinoids has been either banned or suspended in the USA, Germany and France. Italy banned neonicotinoid insecticide use on maize and this led to a halving of winter honey bees deaths over three years.

- There are a range of methods which farmers can use which do not require the use of neonicotinoid pesticides – in Italy government research showed banning neonicotinoid use on maize did not affect farmers' profits.

- UK and EU pesticide safety testing is not of an acceptable standard. First, it relies not on science but on industry data, which is not subject to scientific peer-review and publication. Second, there is no requirement for companies to publish all the research they conduct, with the risk that cherry-picked, favourable studies are used to obtain regulatory approval. Third, no safety testing which looks at the impact of repeated, very low doses (below accepted 'safe' levels) of pesticide are required. Fourth, little or no research is done on the impact of likely combinations of pesticides (the cocktail effect) that insects like honey bees and other insects will actually encounter on farms.

Introduction

1. The Soil Association is a UK charity, campaigning for healthy, humane and sustainable, food, farming and land use. We welcome fact that the EAC has launched this inquiry and we are pleased to have the opportunity to submit evidence to it.

2. *"The world of systematic insecticides is a weird world, surpassing the imaginings of the brothers Grimm... It is a world where the enchanted forest of the fairy-tales has become the poisonous forest in which an insect that chews a leaf or sucks the sap of a plant is doomed."*

   Rachel Carson, Silent Spring (2012 marks the 50th anniversary of the publication of the book).

   Background

3. It is estimated that pollinating insects add some £430 million to the British economy by pollinating crops[1]. Insect pollinated crops have become increasingly important in UK crop agriculture and, as of 2007, accounted for 20% of UK cropland value. Future land use and crop production patterns may further increase the role of pollination services to UK agriculture, highlighting the importance of measures aimed at maintaining both wild and managed species[2].

4. Over the past few years there has been mounting evidence of a global decline in pollinator numbers. There are number of theories for why pollinators have been suffering such declines, including the intensification of agriculture (causing loss of suitable habitats), poor weather and disease. A major cause is thought to be the type and extent of pesticide use on farmland.

5. The University of Reading concluded that: *"even when correctly applied pesticides can have adverse impacts upon bees by reducing their breeding success and resistance to disease, and by reducing the availability of valuable forage plants.[3]"*

6. A relatively new group of insecticides called neonicotinoids has been most strongly implicated. Scientific evidence against these chemicals is strong, which

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[1] http://planetearth.nerc.ac.uk/news/story.aspx?id=988
[2] Pollination services in the UK: How Important are Honeybees?
Breeze T.D., Bailey A.P., Balcombe K.G. and Potts S.G.
Agriculture, Ecosystems & Environment (2011) Vol 142 no. 3-4 (Pages 137-143)
[3] www.foe.co.uk/beesreport

is why some of the individual neonicotinoid pesticides have been suspended on certain crops in several European countries (e.g. France, Germany and Italy). However the UK government has not yet accepted this scientific evidence.

7. Neonicotinoids are a relatively new class of insecticides, launched in 1991. They are synthetic derivatives of nicotine, the tobacco toxin. They are designed to be persistent and target the insect's immune system, binding with its nicotinic receptors and interrupting the sending of nerve impulses. These pesticides are systemic, i.e. they permeate throughout the plant.

8. There are seven different active ingredients: acetamiprid, clothianidin, dinotefuran, imidacloprid, nitenpyram, thiacloprid, and thiamethoxam.

9. The most popular of these is imidaclprid. It is one of the fastest growing insecticides in terms of sales and is one of the most widely used insecticides in the world[4]. It is highly toxic to bees and is the best researched neonicotinoid in terms of the threat is poses to wild pollinators and honey bees.

10. These pesticides are used in a number of ways. The most popular use in the UK is as a seed treatment, in particular for the crops oil seed rape and maize. Scientists are now discovering that very, very low doses of neonicotinoids, well below what European governments consider a 'safe' level of toxic chemical, can disrupt bee behaviour in ways that are likely to be contributing to the collapse in numbers of honeybees, bumble bees and other pollinating insects.

- ***The use (or abuse) of evidence in this particular case, for setting policy and regulations on pesticides.***

11. Methods used during development and initial safety and efficacy testing of pesticides should be changed as it is clear that they are insufficient to demonstrate safety. This is for four main reasons.

12. First, the current UK system of pesticide regulation relies on the use of industry data, which is not subject to scientific peer-review and publication. Second, there is no requirement for companies to publish all the research they conduct, leading to the risk of only cherry picked, favourable studies being used to obtain regulatory approval. Third, no safety testing which looks at the impact of repeated, very low doses (below accepted 'safe' levels) of pesticide are required. Fourth, there is no research on the impact of likely combinations of pesticides (the 'cocktail effect') that insects like honey bees and other insects will actually encounter on farms.

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[4] Yamamoto, I. "Nicotine to Nicotinoids: 1962 to 1997", in *Nicotinoid Insecticides and the Nicotinic Acetylcholine Receptor*, eds. Yamamoto, I. and Casida, J. Springer-Verlag, Tokyo, 1999 pp. 3–27.

13. The continued decline in bird numbers and biodiversity generally in the UK makes it clear that further efforts to reduce pesticide risks and impacts should be prioritised and pursued.

14. The recent draft UK National Action Plan for the Sustainable Use of Pesticides (NAP) highlights the relative lack of concern the UK Government appears to have with regard to pesticide use, as compared to other EU countries. The draft lists existing regulatory measures and non-regulatory initiatives aimed at reducing risks and impacts. In doing so it makes no commitment to change or further reduce pesticide impacts and risks or dependency on the use of pesticides. Contrary to the relevant EU Directive which stipulates that National Action Plans should be "aimed at setting quantitative objectives, targets, measures, timetables and indicators to reduce risks and impacts of pesticide use in human health and the environment" the UK NAP completely fails to implement this requirement.

15. In March 2012 Defra said that it would review the evidence on neonicotinoids and take action if necessary. Before the review was published, Defra's Chief Scientist until September 2012, Professor Sir Bob Watson, acknowledged that the Government's focus on managed honey bees means that it knows a lot less about other pollinators and the effects chemicals may be having on them:

16. *"I fully recognise that the issues that have been raised are not just about honey bees but are relevant to a broader range of bees and pollinator species. We are considering the research in that wider context…we have less baseline knowledge of the effects of all pesticides, not just neonicotinoids, on pollinator species other than honeybees. We also have a less developed basis for interpreting the available evidence."* (Letter to Friends of the Earth, Buglife, Soil Association and ClientEarth, June 2012).

17. The EU as a whole is also taking stronger action with regard to this problem. The European Food Safety Authority (EFSA) has recently published an opinion on how the pesticide risk assessment for bees should be conducted[5]. The body has concluded that neonicotinoid and other systemic insecticides have not been properly evaluated ever since their introduction. The EFSA opinion will form the basis for new guidelines for the tests (to be published in late 2012) required to be carried out by the pesticide manufacturers and how member states should assess the information submitted.

18. These guidelines will only be relevant for new products, or those being reviewed. It is not clear what the situation for systemic insecticides already on the market will be. Individual member states could choose to suspend all neonicotinoid product approvals until the new protocols are introduced. The European Parliament is calling for stronger regulations and a review of the risk assessment, along with more independent research and public scrutiny of the system. We strongly support this approach and urge the UK Government to fully support such calls.

[5] http://bees.pan-uk.org/assets/downloads/Bee_factsheet4.pdf

19. A number of other European countries have recognised the weight of evidence in terms of the case against neonicotinoids.

20. Italy temporarily suspended use of three neonicotinoid products in 2008 – the suspensions have been renewed each year. Research in Italy found that the ban has led to a halving of winter deaths of honeybees over three years. France has recently banned the use of the neonicotinoid, Thiamathoxam, due to concerns about its impact on bees. This chemical remains in use in the UK – in fact its use has increased substantially over the past few years.[6]

21. In France the use of Gaucho (Imidacloprid) on sunflower seeds was banned in 1999 after one third of bees died following its widespread use; in 2004 use on sweetcorn seeds was also banned. Bee populations are reported to have increased again after the ban. In 2012, the French Government announced plans to suspend the neonicotinoid, Thiamathoxam due to concerns about its impact on bees.

22. In 2008 Germany suspended use of some seed treatments containing clothianidin, imidacloprid or thiamethoxam because of mass bee deaths caused by dust arising from seed drilling which drifted crops where bees were feeding.

23. In the US Imidacloprid was voluntarily withdrawn by manufacturers from use on almonds in 2011, under pressure from the state government of California,

- ***The application of real-world – 'field' – data. What monitoring there is of actual – rather than recommended – levels of pesticide usage, and the extent to which that influences policy on pesticides.***

24. Until recently there had been relatively little research using real world 'field' data. We welcome the fact that there is now better evidence for such field risks, yet the UK Government is still not taking such evidence into account strongly enough.

25. The Government's review of evidence with regard to pollinators and neonicotinoids was published on 18th September 2012[7]. The review acknowledged that there was evidence of harm in laboratory studies but that more research is needed in field conditions. It acknowledged the need for more research into impacts on solitary and bumble bees. It recommended changes to the regulatory process to ensure that the risk assessment for pesticide products considers the impact on all bee species, but still took the decision not to suspend or place any restrictions on the use of neonicotinoid pesticides.

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[6] Food and Environment Research Agency (2012) Pesticide Usage Statistics

[7] http://www.defra.gov.uk/publications/2012/09/18/pb13818-pesticides-bees/

Any potential impacts of systemic neonicotinoid insecticides on human health.

26. The impact of systemic neonicotinoid insecticides on human health is a relatively under-researched area. The World Health organisation (WHO) put the neonicotinoids imidacloprid, thiacloprid (the only neonicotinoids listed) as Class II (moderately hazardous).

27. Most neonicotinoids show much lower toxicity in mammals than insects, but emerging science demonstrates that many may also have neurodevelopmental effects, and some are considered likely carcinogens by US Environmental Protection Agency (EPA)[8].

28. The fact that these insecticides are systemic means that they cannot be washed off food. Neonicotinoid pesticides are regularly found in food consumed in the UK. The regular Expert Committee on Pesticide Residues in Food (PRiF) reports show details of the pesticides found in food purchased in the UK. For example the 2010 report shows that the neonicotinoid pesticide imidacloprid was found in grapes, beans and basil. The neonicotinoid which the French Government have recently announced plans to ban (thiamethoxan) was also found in lettuce and grapes. The most recent report (first quarter of 2012, published Sept 2012) showed that imidacloprid was found in beans, broccoli, grapes, lettuce, okra and peppers.[9]

What alternative pest-control measures should be used, such as natural predators and plant breeding for insect-resistance, in a bid to make UK farming more insect- and bee-friendly.

29. There are a wide range of pest-control alternatives to the use of pesticides for insect control.

30. Many crop pest species have natural predators (e.g. ladybirds for aphids) or parasites (e.g. nematodes for slugs and snails). These can be deliberately introduced to a crop or encouraged by providing suitable habitat (e.g. rough un-farmed areas around fields). Often natural predators get removed from the system by pesticides, either directly or through dramatic reduction in prey, resulting in die-off of the predators and subsequently disrupting ecosystems by adversely affecting food webs. Therefore reducing pesticide usage and

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[8]US EPA Factsheets. http://www.epa.gov/ opprd001/factsheets/.
[9]http://www.pesticides.gov.uk/Resources/CRD/PRiF/Documents/Results%20and%20Reports/2012/Q1%202012%20Final.pdf

encouraging natural predators can help control pest species as well as improving the health of the whole ecosystem.

31. Methods such as crop rotations, (as opposed to monocultures) and a variety of measures to encourage natural predators of pest species are widely used in farming worldwide.

32. Such methods are widely used in organic farming, which does not use neonicotinoids and does not rely on pesticide use. Biodiversity, in terms of a wide range of plants, insects and animals, is key to organic farming. Each plant or animal has a specific role in the life of the farm, and this is especially true of the bee. Bees and other pollinators play a crucial role in pollination, so that we can grow fruits and vegetables.

33. Intensive agricultural techniques are causing such concern that new research is being carried out at the laboratory of Apiculture and Social Insects at the University of Sussex. Professor Francis Ratnieks, who heads the laboratory stated: "The use of herbicides and intensive forms of agriculture means that fields of wheat and barley now have few weeds. Fields of grass now have few wild flowers, clover is less used and much of the heather moors have been ploughed up.[10]"

34. The focus on natural ecosystems and native species, as well as the lack of pesticides used in organic farming, make it a haven for pollinators. Organic farms also provide the wild spaces at not just at field margins and in hedgerows, where bees nest and shelter, but also providing a diversity of flowers and habitats for bees to feed throughout the field.

35. In particular, red and white clover are mainstays of organic farming systems. Red clover (*Trifolium pratense L.*) is used extensively as part of the rotational farming systems that maintain soil fertility without the use of chemical fertilisers. In addition it is one of the bumble bees favourite foods. White clover (*Trifolium repens*) is also found in abundance on organic farms. Honeybees are particularly drawn to this plant.

36. "In the economy of nature the natural vegetation has its essential place...Such vegetation is the habitat of wild bees and other pollinating insects. Man is more dependent on these wild pollinators then he usually realises. Even the farmer himself seldom understands the value of wild bees and often participates in the very measures that rob him of their services….These insects, so essential to our agriculture and indeed to our landscape as we know it, deserve something better from us than the senseless destruction of their habitat. Honeybees and wild bees depend heavily on such weeds".

Rachel Carson, Silent Spring.

[10] http://www.sussex.ac.uk/lasi/sussexplan/agriculture

Annex 1

In 2009 the NGO Buglife wrote a detailed overview of the evidence in this area: 'The impact of neonicotinoid insecticides on bumblebees, honey bees and other non-target invertebrates[11]'.

Since then, a number of other scientific research papers have been published which add further evidence. A selection of these is outlined below.

Title: Neonicotinoid Pesticide Reduces Bumble Bee Colony Growth and Queen Production
Authors: Penelope R. Whitehorn, Stephanie O′Connor, Felix L. Wackers, Dave Goulson
Journal: *Science* (2012); vol 336 no. 6079 (pages 351-352)
DOI: 10.1126/science.1215025
Summary: Exposed colonies of the bumble bee Bombus terrestris in the laboratory to field-realistic levels of the neonicotinoid **imidacloprid**, then allowed them to develop naturally under field conditions. Treated colonies had a significantly reduced growth rate and suffered an 85% reduction in production of new queens compared with control colonies.

Title: A Common Pesticide Decreases Foraging Success and Survival in Honey Bees
Authors: Mickaël Henry, Maxime Beguin, Fabrice Requier, Orianne Rollin, Jean-François Odoux, Pierrick Aupinel, Jean Aptel, Sylvie Tchamitchian, Axel Decourtye
Journal: Science (2012); vol 336 no. 6079 (pages 348-350)
DOI: 10.1126/science.1215039
Summary: Exposed on free-ranging honeybee foragers labeled with a RFID tag to non-lethal levels of **thiamethoxam** (neonicotinoid pesticide) resulting in high mortality due to homing failure. Levels of mortality were high enough to put a colony at risk of collapse.

Title: *In situ* replication of honey bee colony collapse disorder
Authors: Chensheng Lu, Kenneth M. Warchol, Richard A. Callahan
Journal: Bulletin of Insectology (2012) Vol 65 n. 1 (pages 99-106)
ISSN: 1721-8861
Summary: 16 hives were treated with **imidacloprid**, at dosages reflecting imidacloprid residue levels reported in the environment previously. Treatment lasted for 13 weeks after which all hives were alive. However, after 23 weeks 15 of 16 imidacloprid treated

11 http://www.buglife.org.uk/Resources/Buglife/Documents/PDF/REVISED%20Buglife%20Neonicotinoid%20Report.pdf

hives (94%) were dead. Dead hives were remarkably empty except for stores of food and some pollen left, a resemblance of CCD. The survival of the control hives that were managed alongside with the pesticide-treated hives suggests this was down to the treatment and not other environmental factors.

Title: Pesticide exposure in honey bees results in increased levels of the gut pathogen Nosema
Authors: Jeffery S. Pettis, Dennis vanEngelsdorp, Josephine Johnson & Galen Dively
Journal: Naturwissenschaften (2012) Vol 99 no.2 (pages 153–158).
DOI: 10.1007/s00114-011-0881-1
Summary: Exposed honey bee colonies over three brood generations to sub-lethal doses of **imidacloprid**, and then subsequently challenged newly emerged bees with the gut parasite, *Nosema spp.* The pesticide dosages used were below levels demonstrated to cause effects on longevity or foraging in adult honey bees. *Nosema* infections increased significantly in the bees from pesticide-treated hives when compared to bees from control hives demonstrating an indirect effect of pesticides on pathogen growth in honey bees. Interactions between pesticides and pathogens could be a major contributor to increased mortality of honey bee colonies, including colony collapse disorder, and other pollinator declines worldwide.

Title: Influence of dinotefuran and clothianidin on a bee colony
Authors: Toshiro Yamada, Kazuko Yamada & Naoki Wada
Journal: Japanese Journal of Clinical Ecology (2012) Vol.21 No.1 (pages 10-23)
Summary: Treated eight colonies of ~10,000 honeybees with **dinotefuran** or **clothianidin**. Treatments were foods containing **dinotefuran** of 1 ppm to 10 ppm or **clothianidin** of 0.4 ppm to 4 ppm fed into a beehive. Three levels of concentration for each pesticide were 10, 50 and 100 times lower than that in practical use. The changes of adult bees, brood and the pesticide intake in each colony were examined and suggest that each colony with the pesticide administered collapses to nothing after passing through a state of CCD. The high-concentration pesticides seem to work as an acute toxicity and the low- and middle-concentration ones do as a chronic toxicity.

Title: Multiple Routes of Pesticide Exposure for Honey Bees Living Near Agricultural Fields
Authors: Christian H. Krupke, Greg J. Hunt, Brian D. Eitzer, Gladys Andino, Krispn Given
Journal: PLoS ONE Vol 7 no.1: e29268.
DOI: 10.1371/journal.pone.0029268
Summary: Neonicotinoid insecticides have been found in previous analyses of honey bee pollen and comb material but the routes of exposure have remained largely undefined. Used LC/MS-MS to analyze samples of honey bees, pollen stored in the hive and several potential exposure routes associated with plantings of neonicotinoid treated maize. The results demonstrate that bees are exposed to these compounds and several other agricultural pesticides in several ways throughout the foraging period. During spring, extremely high levels of **clothianidin** and **thiamethoxam** were found in planter exhaust material produced during the planting of treated maize seed. Neonicotinoids were also found in the soil of each field we sampled, including unplanted fields. Plants visited by foraging bees (dandelions) growing near these fields were found to contain

neonicotinoids as well. This indicates deposition of neonicotinoids on the flowers, uptake by the root system, or both. Dead bees collected near hive entrances during the spring sampling period were found to contain **clothianidin** as well, although whether exposure was oral (consuming pollen) or by contact (soil/planter dust) is unclear. We also detected the insecticide **clothianidin** in pollen collected by bees and stored in the hive. When maize plants in our field reached anthesis, maize pollen from treated seed was found to contain **clothianidin** and other pesticides; and honey bees in our study readily collected maize pollen. These findings clarify some of the mechanisms by which honey bees may be exposed to agricultural pesticides throughout the growing season.

Title: RFID Tracking of Sublethal Effects of Two Neonicotinoid Insecticides on the Foraging Behavior of Apis mellifera
Authors: Christof W. Schneider, Ju¨ rgen Tautz, Bernd Gru¨ newald, Stefan Fuchs
Journal: PLoS ONE (2012) volume 7 No1: e30023.
DOI: 10.1371/journal.pone.0030023
Summary: In addition to testing according to current guidelines designed to detect bee mortality, tests are needed to determine possible sublethal effects interfering with the animal's vitality and behavioral performance. Several methods have been used to detect sublethal effects of different insecticides under laboratory conditions using olfactory conditioning. Furthermore, studies have been conducted on the influence insecticides have on foraging activity and homing ability which require time-consuming visual observation. This experiment tested an experimental design using the radiofrequency identification (RFID) method to monitor the influence of sublethal doses of insecticides on individual honeybee foragers on an automated basis. Electronic readers were positioned at the hive entrance and at an artificial food source to obtain quantifiable data on honeybee foraging behavior. This gave detailed information on flight parameters. By comparing several groups of bees, fed simultaneously with different dosages of a tested substance it was possible to monitor the acute effects of sublethal doses of the neonicotinoids imidacloprid (0.15–6 ng/bee) and clothianidin (0.05–2 ng/bee) under field-like circumstances. Both substances led to a significant reduction of foraging activity and to longer foraging flights at doses of ≥0.5 ng/bee (clothianidin) and ≥1.5 ng/bee (imidacloprid) during the first three hours after treatment. This study demonstrates that the RFID-method is an effective way to record short-term alterations in foraging activity after insecticides have been administered once, orally, to individual bees. Field relevant doses of imidacloprid in sunflowers and oilseed rape were estimated to be around 0.13 ng and 0.023–0.03 ng, respectively. At these doses there was no effect of treatment.

Title: Combined pesticide exposure severely affects individual- and colony-level traits in bees
Authors: Richard J. Gill, Oscar Ramos-Rodriguez & Nigel E. Raine
Journal: Nature (2012)
DOI: doi:10.1038/nature11585
Summary: Reported widespread declines of wild and managed insect pollinators have serious consequences for global ecosystem services and agricultural production. Bees contribute approximately 80% of insect pollination, so it is important to understand and mitigate the causes of current declines in bee populations. Recent studies have

implicated the role of pesticides in these declines, as exposure to these chemicals has been associated with changes in bee behaviour and reductions in colony queen production. However, the key link between changes in individual behaviour and the consequent impact at the colony level has not been shown. Social bee colonies depend on the collective performance of many individual workers. Thus, although field-level pesticide concentrations can have subtle or sublethal effects at the individual level, it is not known whether bee societies can buffer such effects or whether it results in a severe cumulative effect at the colony level. Furthermore, widespread agricultural intensification means that bees are exposed to numerous pesticides when foraging, yet the possible combinatorial effects of pesticide exposure have rarely been investigated

These experiments show that chronic exposure of bumblebees to two pesticides (neonicotinoid and pyrethroid) at concentrations that could approximate field-level exposure impairs natural foraging behaviour and increases worker mortality leading to significant reductions in brood development and colony success. It was found that worker foraging performance, particularly pollen collecting efficiency, was significantly reduced with observed knock-on effects for forager recruitment, worker losses and overall worker productivity. Moreover, this provides evidence that combinatorial exposure to pesticides increases the propensity of colonies to fail.

The importance of Insect pollinators

Title: Pollination services in the UK: How Important are Honeybees?
Authors: Breeze T.D., Bailey A.P., Balcombe K.G. and Potts S.G.
Journal: Agriculture, Ecosystems & Environment (2011) Vol 142 no. 3-4 (Pages 137-143)
DOI: 10.1016/j.agee.2011.03.020
Summary: Insect pollinated crops have become increasingly important in UK crop agriculture and, as of 2007, accounted for 20%of UK cropland and 19% of total farmgate crop value. Analysis of honeybee hive numbers indicates that current UK populations supply 34% of pollination services, falling from 70% in 1984. In spite of this decline, insect pollinated crop yields have risen by 54% since 1984. Future land use and crop production patterns may further increase the role of pollination services to UK agriculture, highlighting the importance of measures aimed at maintaining both wild and managed species.

Title: Contribution of Pollinator-Mediated Crops to Nutrients in the Human Food Supply
Authors: Elisabeth J. Eilers, Claire Kremen, Sarah Smith Greenleaf, Andrea K. Garber, Alexandra-Maria Klein
Journal: PLoS ONE (2011) Vol 6 no. 6: e21363.
DOI: 10.1371/journal.pone.0021363
Summary: This study evaluates the nutritional composition of animal-pollinated world crops. By calculating pollinator dependent and independent proportions of different nutrients of world crops, revealed that crop plants that depend fully or partially on animal pollinators contain more than 90% of vitamin C, the whole quantity of Lycopene and almost the full quantity of the antioxidants b-cryptoxanthin and b-tocopherol, the majority of the lipid, vitamin A and related carotenoids, calcium and fluoride, and a large portion of folic acid. On-going pollinator decline may exacerbate current difficulties of providing a nutritionally adequate diet for the global human population.

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