Maine Board of Pesticides Control

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A popular fly bait is being misused to kill raccoons and other animals.

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Regulators move to limit wildlife deaths from misuse of deadly fly killer

By Nala Rogers | Feb. 18, 2016 , 3:45 PM

This past May, a dog named Gunner wandered into his neighbor's barn and lapped sweet blue liquid from two pie tins on the floor. Then he collapsed and started to convulse. When Gunner's veterinarian heard the story, he immediately guessed what was in the tins, according to a case summary from the Office of Indiana State Chemist (OISC). It was a mixture of Coca Cola and methomyl, a chemical sold to attract and kill flies.

Gunner eventually recovered, but other animals have been less lucky. Over the past few decades, wildlife researchers and environmental regulators in the United States have become increasingly alarmed by the intentional misuse of methomyl to kill "nuisance" wildlife including skunks and raccoons. Sometimes, however, the victims include dogs, cats, and even bald eagles.

"It's indiscriminate, intentional poisoning of wildlife," says Brian Rowe, who recently retired as pesticide section manager at the Michigan Department of Agriculture & Rural Development in Lansing. "Some of them die with their face in the pan that they're licking out of. I mean, it kills them that quick."

In response, this week Michigan officials are considering new rules to limit the use of the pesticide. If the rules are approved, as expected, Michigan would join a growing number of states and the federal Environmental Protection Agency (EPA) in trying to prevent the misuse of methomyl, in part by restricting who can buy it and requiring new warning labels. But some observers fear the labels—which depict a raccoon in a red circle with a slash through it—might unintentionally make matters worse.

Methomyl, which first hit the market in 1966, has a broad range of uses, including killing pests in agriculture. Under federal and state law, only licensed applicators can purchase and use the most potent methomyl products. But fly baits, which contain relatively low concentrations of methomyl, are available to everyone. The baits— commonly sold under the trade names Golden Malrin, Lurectron Scatterbait, and Stimukil—are designed to be placed in fly-prone areas, such as livestock enclosures.

Consumers, however, soon figured out that the baits could be repurposed for what is often called "critter control" on internet message boards. The poison is especially popular among sweet corn growers who are having trouble with raccoons, Rowe says, although people have employed it in attempts to kill everything from rodents to wolves. Rowe has documented more than 50 examples of people swapping advice and poison recipes online, and as of January, instructions for how to kill raccoons with methomyl are still among the first results of a Google search for "Golden Malrin."

Rowe first heard about misuse of fly bait in the 1990s, and he started raising the issue with state and federal regulators in 2006. At first, it was hard to get anyone to take it seriously, he says. People dismissed it as a local problem, even though more than half of states that responded to Rowe's inquiries confirmed they had at least one incident on record.

Between 2010 and 2012, regulators in Michigan and Indiana decided to see how deep the problem went. Agents posed as customers in hardware and farm supply stores, asking how to get rid of skunks or raccoons. In about a quarter of cases, the salespeople recommended fly bait. One store even had a sign: "Golden Malrin®—Kills Groundhogs, Opossums and Raccoons —One cup fly bait and one can regular coke."

"We didn't think it was a problem in Indiana … and then finally when we started looking, we said holy smokes, it is a problem," says Leo Reed, a certification and licensing manager at OISC in West Lafayette. "Our contention is that if methomyl [fly bait] is being sold in your state, it's being misused in your state."

Starting in 2010, the six states in EPA's Region 5, a regulatory region that includes Indiana and Michigan, joined forces to call for change from EPA. Their proposed solution: Reclassify methomyl fly baits as "restricted use" products. This would get the poison out of the hands of the general public, limiting access to trained, licensed applicators and the people they supervise.

The fly bait companies opposed that solution, however, and instead reached a compromise with EPA in April 2015. By early 2017, the agreement calls for the companies to stop distributing methomyl fly baits to general retailers such as hardware stores, and to stop making small containers. Farm supply stores will still be able to sell larger 4.5- and 18-kilogram containers, which will come with new warning labels and explanatory pamphlets. The companies and EPA plan to monitor reports of misuse through 2020, and further restrict use to licensed applicators if incidents aren't "significantly reduced."

The maker of one of the products, Golden Malrin, says the arrangement makes sense. "[Golden Malrin] is an important tool in reducing fly populations which have the potential to spread disease to livestock and humans," wrote Mark Newberg, a representative for Wellmark International in Schaumburg, Illinois, which produces Golden Malrin, in an email. "We did what was asked of us by the EPA to keep the product available as a fly insecticide."

Methomyl products will now carry this logo, meant to warn against using them to poison raccoons. But some observers worry it might carry the opposite message.

Some observers, however, have questions about the new warning labels. The red raccoon symbol is meant to be eye-catching, and according to EPA it means “not for use on raccoons.” But in some people’s eyes, it looks more like it is advertising the chemical as a good way to get rid of raccoons.

“Isn’t that the best advertisement for misuse you can possibly have?” Indiana’s Reed says. When he described the symbol at a meeting of regulators last year, participants started laughing.

The image could be misinterpreted, says Andrea Rother, an environmental and occupational health specialist at the University of Cape Town in South Africa who studies how people interpret symbols on pesticide labels. Before adopting the raccoon symbol, she says, the companies or EPA should have tested it with consumers.

EPA officials say no such testing occurred, but are confident that people will read the new labels as intended. The agency notes that text below the symbol reads "it is illegal to use this product with the intention to kill raccoons, skunks, opossums, coyotes, wolves, dogs, cats, or any other non-target species."

"We believe that these two warnings together will make it clear that these uses are not legal," wrote an EPA spokesperson in an email.

Even if consumers do get the right message, they're unlikely to change their behavior, Rother predicts. People who use fly bait to poison raccoons already know they aren't following label directions. The most effective way to combat such deliberate misuse, she says, is to limit people's access.

Some states are doing just that, going beyond EPA's mitigation measures and instead making the products illegal for sale to the general public. Indiana reclassified methomyl fly baits as restricted use products in 2013. Michigan is following suit, with a hearing to finalize the restrictions scheduled for 19 February.

In the rest of the country, Rowe expects illegal poisonings to continue, at least while current EPA rules are in place. It will fall on researchers and regulators to document and report such incidents, he says, so that the companies and the EPA will have the data they need in 2020 to determine if the existing restrictions are working.

Posted in: **Plants & Animals**, **Science and Policy**

DOI: 10.1126/science.aaf4082

Nala Rogers

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South Portland to consider pesticides ordinance

www.pressherald.com/2016/02/29/south-portland-to-consider-pesticides-ordinance/

By Kelley Bouchard Staff Writer | @KelleyBouchard | 207-791-6328

SOUTH PORTLAND — Property owners here may soon be limited in the chemicals they can use to control lawn and garden pests and weeds under a partial pesticide ban that the City Council is set to review Monday.

The proposed ordinance would prohibit the use of synthetic pesticides and herbicides on city-owned and private property, but it wouldn't apply to pesticides permitted in organic farming or exempted from federal regulation.

The ordinance would be phased in over two years, promoted by a Pest Management Advisory Committee and enforced with fines levied by the city's code enforcement officer.

"The draft ordinance represents an earnest attempt by (municipal) staff to balance public health and environmental protection with aesthetic expectations for public and private landscape management," said Julie Rosenbach, the city's sustainability coordinator, in a memo that accompanies the proposed ordinance.

The council is scheduled to review the ordinance during a 6:30 p.m. workshop at City Hall.

The ordinance was drafted at the council's direction by Rosenbach, Sarah Neuts, the city's director of parks, recreation and waterfront, and Fred Dillon, the city's stormwater program coordinator. They studied a wide variety of research and regulations and interviewed many officials and stakeholders, including private landscaping contractors.

"We focused on drafting an ordinance that is bold but realistic," Rosenbach wrote.

The ordinance doesn't specifically name pesticides that would be allowed or prohibited; it would prohibit the use of synthetic pesticides other than products allowed by the Organic Materials Review Institute or exempt from regulation by the U.S. Environmental Protection Agency.

It would, for instance, prohibit most property owners from using glyphosate, the active ingredient in Monsanto's Roundup weed killer. While the EPA says glyphosate is "safe" when used correctly, the International Agency for Research on Cancer last year classified it as "probably carcinogenic."

PARTIAL PESTICIDE BAN

The ordinance wouldn't apply to the sale of pesticides or their use in commercial agriculture, on golf courses or to kill poisonous plants and biting, destructive or disease-carrying insects. Exempted pesticides would include pet flea and tick treatments, disinfectants and germicides, insect repellents, rodent control supplies, swimming pool chemicals, aerosol products, and paints, stains and sealants.

The proposed ordinance doesn't address fertilizers, which environmentalists say are flowing into Casco Bay and harming valuable ecosystems. City officials plan to address fertilizer use in a future ordinance.

"We're not letting go on that," said Rachel Burger, founder and president of Protect South Portland, a group that has been pushing for environmental action on several fronts.

"The pesticides ordinance is just step one," Burger said. "I'm very pleased with it. It's beautifully written, well thought out and very positive."

Twenty-six Maine communities, including Ogunquit, Brunswick, Rockland, Wells, Lebanon and Waterboro, have pesticide-control ordinances that ban or regulate the type or method of pesticides used in municipal, agricultural and forestry applications, and near drinking-water supplies.

Ogunquit is the only town to extend its ordinance broadly to include all private property owners. However, like South Portland's proposed ordinance, it's not an outright ban. It allows restricted pesticides to be used to kill noxious or invasive plants, such as poison ivy, and to address health and safety threats, such as disease-carrying insects.

Last fall, the Montgomery County Council in Maryland restricted the use of "cosmetic pesticides" on private lawns, on certain county land, and at child-care facilities and playgrounds. Some provinces and hundreds of municipalities across Canada have taken similar steps, along with anti-pesticide measures in France, Germany and the Netherlands.

OPPOSITION FROM APPLICATORS

Released Friday, South Portland's proposed ordinance drew immediate opposition from Mainers for Greener Communities, a coalition of nurseries, landscapers, turf companies, arborists, golf course managers and pesticide applicators.

"This proposal is not based in science and would make South Portland only the third community in the nation to regulate what people put on their own lawns," coalition leader Jesse O'Brien, owner of Down East Turf Farm in Kennebunk, said in a prepared statement. "Communities with similar policies for city property found a significant degradation in the quality of athletic fields and a two- to threefold increase in maintenance costs."

The ordinance would apply to city property during the first year and broaden to private property during the second year. It would be reviewed during the third year for possible revision. Following an initial warning, violators would face escalating fines of $200, $500 and $1,000 per offense.

Property owners could apply to the city for waivers to use pesticides when public health or safety is threatened. If a waiver were approved, the property owner would have to post signs notifying neighbors of the date, time and type of pesticide applied. Licensed applicators would have to submit annual reports to the city providing detailed information on each use of synthetic pesticides.

The ordinance would call for a broad public education campaign including notices, posters, brochures, workshops and training sessions for homeowners, retail employees and others.

"It's a cultural change," Burger acknowledged. "It's going to be a big learning curve, but it's an exciting one."

City Council Workshop | Agenda Item #2
February 29, 2016 | Pesticides Ordinance

At the June 8, 2015 workshop, the Council heard a presentation put together by Protect South Portland around the use of pesticides. Protect South Portland was joined by Jay Feldman, from Beyond Pesticides in Washington DC; Chip Osborne, of Osborne Organics LLC in Marblehead, MA; and Mary Cerullo, Associate Director, of the Friends of Casco Bay. Each talked about the harmful effects of pesticide use and the negative impacts to the environment. Alternative methods were presented as a means of providing another way for lawn care/vegetation maintenance.

The City Council voiced support for pursuing a pesticide ordinance and various types of ordinances were presented and discussed at the July 13, 2015 workshop. A pesticide ordinance committee consisting of Sustainability Coordinator Julie Rosenbach, Parks, Recreation & Waterfront Acting Director Sarah Neuts and Stormwater Program Coordinator Fred Dillon was created and proposed ordinance language was developed (attached), which will be discussed at next Monday's workshop.

Included is a memorandum from Julie Rosenbach which includes an outline of the process taken to develop the ordinance. The committee members will be at Monday's meeting to answer any questions.

James H. Gailey

City Manager

SUSTAINABILITY OFFICE

JULIE A. ROSENBACH
Sustainability Coordinator

To: James H. Gailey, City Manager

From: Julie Rosenbach, South Portland Sustainability Coordinator

CC: Fred Dillon, South Portland Stormwater Program Coordinator
Sarah Neuts, Acting Director, Parks, Recreation & Waterfront

Date: February 22, 2016

Subject: Draft Ordinance to Ban the use of Pesticides

Following a City Council Workshop this past summer on organic landscaping and lawn care practices (June 8, 2015) and subsequent workshop to review different types of pesticide ordinances (July 13, 2015), the City Council directed staff to develop an ordinance that greatly reduces and potentially eliminates the use of synthetic pesticides throughout most of the City.

Over the next six months, the designated staff draft pesticide ordinance committee (consisting of myself, Sarah Neuts, Parks Department Superintendent and Fred Dillon, Stormwater Program Coordinator) reviewed numerous documents and conducted several interviews with groups and individuals including policy makers, practitioners, local advocates and industry representatives to develop a draft ordinance. **The attached memo summarizes our process and key considerations for the Council.**

The draft ordinance, completed in January 2016, represents an earnest attempt by staff to balance public health and environmental protection with aesthetic expectations for public and private landscape management.

To summarize, we focused on drafting an ordinance that is bold but realistic.

We relied on the precautionary principle to guide our efforts, acknowledging that while the science regarding risks associated with synthetic pesticides is not settled, there are enough studies linking these products to reproductive disorders, birth defects, learning disabilities, neurological disease, endocrine disorders, and cancer to warrant a ban with minimal exemptions.

At the same time, we recognize there may be situations we have not and cannot anticipate so we included a waiver process in the ordinance and designed it to be a living document that is revisited in year 3 and adjusted as needed.

SUSTAINABILITY OFFICE

JULIE A. ROSENBACH
Sustainability Coordinator

We included a long implementation period to allow sufficient time for a successful transition in our thinking and practices. It is also important to note that during the transition phase lawn and turf conditions may appear to get worse before they get better because it takes time to (re)build a healthy and resilient ecosystem which is not dependent on synthetic chemicals.

Recognizing that any meaningful reduction of synthetic pesticides will depend on the cooperation of residents and local businesses, we included a robust education and outreach section. Because the ordinance will involve a culture change as much as a policy change, we believe the strong education and outreach section balances the challenges inherent to enforcement.

The overarching goal of the ordinance is to reduce toxics in our community by reducing the use of synthetic pesticides and promoting a transition to organic land care practices. The Council's review of the ordinance and subsequent public input may provide further refinement, which staff are ready to incorporate.

Lastly, as you may know a bill (LD 1543) was introduced at the state level which would require municipalities to create a "municipal reviewing authority that is similar to the Board of Pesticides Control" in order to pass any type of local ordinance. The Maine Municipal Association (MMA) voted to oppose this bill at their last meeting, and Maine's Environmental Priorities Coalition has made it one of their four priority bills. The bill was assigned to the State and Local Government Committee but then tabled pending review, where it has remained. The bill is expected to remain tabled this session.

Respectfully,

Julie Rosenbach
Sustainability Coordinator

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South Portland Draft Pesticide Ordinance
Process & Key Considerations

BACKGROUND

In early June of 2015, the nonprofit group Protect South Portland sponsored a presentation to the City Council by proponents for organic landscaping and lawn care practices. The goal of this initiative was to encourage the Council to consider establishing an ordinance that greatly restricts or eliminates the use of synthetic pesticides and fertilizers throughout most of the City in recognition of growing concerns about adverse impacts from the use of these materials on public health and the environment.

The Council held a subsequent meeting in July 2015 to allow for public comment. The majority of speakers favored the creation of an ordinance that would ban the use of synthetic pesticides in most cases. Individuals who expressed reservations with a pesticide ban generally represented commercial landscaping and lawn care interests and favored an Integrated Pest Management (IPM)[1] approach rather than an outright ban of synthetic pesticides. All of the Councilors supported the creation of an ordinance to regulate synthetic pesticide use with some strongly preferring an outright ban and others favoring a more moderate approach. Following extensive coverage in local newspapers, the City Manager subsequently received more balanced comments for and against a ban on synthetic pesticides.

Shortly after the July 2015 Council meeting, an intern for the City Manager developed an initial draft pesticide ordinance based on several similar documents developed by communities throughout the State and elsewhere in the country. The City Manager then appointed a committee consisting of the Sustainability Coordinator, the Parks & Recreation Department Superintendent and the Stormwater Program Coordinator to further develop and refine the draft ordinance based on more in-depth research.

Staff reviewed numerous documents and conducted several interviews with groups and individuals including policy makers, practitioners, local advocates and industry representatives to finalize the draft ordinance. The discussion below summarizes the rationale and most significant findings for the final draft document that the Council will consider in early 2016.

INTRODUCTION

Given the Council's consensus that synthetic pesticide use in South Portland should either be restricted or eliminated, staff relied on the ***precautionary principle*** to guide their efforts

[1] Integrated Pest Management consists of practices that emphasize quality production and health while minimizing reliance on pesticides.

in developing the draft ordinance. The precautionary principle acknowledges that while there may be conflicting scientific claims about the relative risks associated the use of potentially harmful products, erring on the side of caution by reducing the use of these products is justified to protect public health and the environment – particularly when the costs to do so are not excessive. Staff considered the four central tenets of the precautionary principle[2] when drafting the ordinance:

- Taking preventative action in the face of uncertainty
- Shifting the burden of proof to the proponents of an activity
- Exploring a wide range of alternatives to possibly harmful actions
- Increasing public participation in decision making

Even though monitoring for synthetic pesticides in South Portland has been limited, there is evidence that these chemicals are a potential cause for concern. There is also an increasing body of research both nationally and globally that synthetic pesticides are having detrimental effects on human health and the environment.

The draft ordinance addresses these concerns by greatly restricting synthetic pesticide use and promoting organic landscaping and lawn care practices to prevent pest problems. The ordinance also stresses the importance of education and outreach in recognition that any meaningful reduction of potentially harmful chemical use depends on the cooperation of residents and local businesses.

Thus, the overarching goal of the ordinance is to reduce toxics in our community by reducing the use of synthetic pesticides and promoting a transition to organic land care practices. In so doing, the ordinance will protect people, pets and the environment.

PROCESS FOR DEVELOPING DRAFT ORDINANCE

In the process of developing South Portland's draft ordinance, staff reviewed a wide variety of information sources including (but not limited to):

- ***Academic research studies and summaries:*** policy implementation evaluation of Toronto's municipal bylaw; study on state regulations, organic lawn management, and nutrient accumulation in soils; journal article on the precautionary principle and its applications; and Rutgers University paper on the management of turf grass using 'low-impact' pesticides.
- ***Local, state and federal regulations and guidance documents:*** Maine Board of Pesticide Control; Environmental Protection Agency; Canada Ministry of Environment; European Union; Washington State Dept. of Agriculture; and several municipal ordinances.

[2] *The Precautionary Principle in Environmental Science* (Sept. 2001 Environmental Health Perspectives)

- ***Non-governmental organization interviews and reference documents:*** Beyond Pesticides; Friends of Casco Bay; Casco Bay Estuary Partnership; Maine Organic Farmers and Gardeners Association; and the Northeast Organic Farming Association.
- ***Interviews with local and state governmental officials:*** Takoma Park MD; Ogunquit ME; and the Cumberland County Soil and Water Conservation District.
- ***Interviews with private landscaping contractors:*** Ornamental Horticulture Council; Maine Landscape and Nursery Association; Down East Turf; Lucas Tree; Sable Oaks Golf Course; Scotts Lawn Care; Broadway Gardens; Osborne Organics; and Go Green Landscaping.

This in-depth process included detailed discussions by staff about which provisions to include in the draft ordinance. From mid-July until late December, staff met on a weekly (and occasionally biweekly) basis to carefully consider all elements in the draft ordinance. The most substantive discussion topics and resulting decisions – all of which were reached by consensus – are summarized below.

Fertilizers: after extensive research and careful consideration, staff decided that developing a comprehensive management strategy to protect water resources from nutrient runoff (esp. nitrogen) should be addressed through a separate stand-alone ordinance. Virtually all municipalities with fertilizer ordinances have also adopted this approach. Given the increasing concerns about adverse impacts from excessive nitrogen inputs to Casco Bay, staff believe that developing a draft fertilizer ordinance would be a significant next step.

Provisions: Following the National Organic Program, the provisions of the ordinance are centered around natural and organic practices. In general, synthetic pesticides are prohibited unless specifically permitted and organic products are permitted unless specifically prohibited. It is also important to emphasize that "organic" is not synonymous with safe. There are risks associated the misuse and overuse of organic pesticides that can also result in adverse impacts to human health and the environment, although the risks are generally considered to be lower than those associated with synthetics.

Exemptions and Waivers: While the goal of the ordinance is to make organic pest management the primary management tool in our community, staff recognize that exemptions are necessary to ensure a successful transition. South Portland’s draft ordinance allows for two exemption areas – which is less than most other municipal ordinances.

- Public Health and Safety Protection: there may be potential situations requiring the use of synthetic pesticides because there are currently no comparable organic alternatives available. The protection of public health and safety are paramount and there are numerous circumstances that potentially qualify for an exemption as described in the ordinance.

- Golf Courses: there are currently few (if any) examples of golf courses that are being managed successfully without some synthetic pesticide use. Consequently, golf course playing surfaces have also been exempted until organic turf management practices become better established and proven. The City may want to consider creating a pilot program to test various organic practices at the municipal course prior to requiring these practices on a more widespread basis.

Waiver applications will be required for situations involving the protection of public health and safety. A Pesticide Management Advisory Committee (PMAC) will review these applications to ensure that the waiver requests are justified based on a lack of viable alternatives. The PMAC must find that three conditions exist prior to granting and/or approving a waiver; these conditions align with Shoreland Overlay Districts (article XIII) standards in our zoning ordinance.

Staff decided against exempting athletic playing fields primarily because of the higher likelihood that young athletes could come into direct contact with pesticides. Additionally, there are several examples in other communities where these areas are being managed successfully using organic pest management practices. There may also be grant funds available to assist the City in implementing these practices for our fields.

Public Notification: For instances when synthetic pesticides are allowed (through the waiver review process), the ordinance includes a detailed notification section that applies to both licensed applicators and private citizens. Staff believe this is an important provision because the public has a right to know when and where these chemicals are being applied.

Reporting: Even though the ordinance should greatly reduce synthetic pesticide use and potential exemptions will (hopefully) be few and infrequent, a reporting requirement is included to provide ongoing tracking data for the use of these chemicals. The City's Parks & Recreation Department already maintains detailed records for when, where, how much and what kind of synthetic pesticides are used on City properties. The ordinance will require landscaping contractors to annually report with the same level of detail for private properties.[3] Staff also discussed requiring individual residents to provide synthetic pesticide usage data but recognized this would likely create an undue administrative burden.

Phasing: The phasing section allows for a transition period and begins with public properties to demonstrate the City's commitment to leading by example. There is a one

[3] Landscaping contractors we met with stated that they already keep this data so it would not be overly burdensome to report it.

year lag period so municipal departments can test new practices and products. Phase 2 applies to all private property and begins after two years. Golf courses were initially considered for a third phase but there are currently not enough proven organic management practices to ensure that course playing surfaces could be maintained adequately. Consequently, emphasis was placed on data collection and management practices to inform future provisions. Since the ordinance is intended to be a living document, Phase 3 instead focuses on evaluating the effectiveness of the pesticide regulations and revising them as needed based on the condition of public land, community feedback, new information and emerging science.

Outreach and Education: Education alone has not proven successful in reducing the use of synthetic pesticides. According to the Maine Board of Pesticide Control, the use of pesticides for residential land care has increased nearly sevenfold over the past twenty years. However, other municipalities have demonstrated that ordinances combining education with enforcement can be successful tools for setting new community standards.

Because the ordinance will be a culture change as much as a policy change, staff believe a strong outreach and education section balances the challenges inherent to enforcement. The behavior change approach outlined in the ordinance targets different segments of the population through diverse means and includes education for and through retailers. This provision in particular targets private citizens who are the least likely to have any knowledge or training about the hazards associated with synthetic pesticide use.

Staff also considered including provisions to require training and certification on organic land care for landscaping contractors but decided against it given that state law already requires all applicators of synthetic pesticides to be certified. However, the City may want to consider lobbying the Maine Board of Pesticides Control to establish an Organic Pest Management (OPM) certification program.

Authority: The Pesticide Management Advisory Committee (PMAC) has a lofty charge. The committee's success will depend largely on the effectiveness of their outreach and education strategy, which will require funding to develop and implement.

CONCLUSION

Following the public meetings earlier this year, the City Council directed the Manager to establish an ordinance that greatly reduces and potentially eliminates the use of synthetic pesticides throughout most of the City. The draft ordinance completed in January 2016 represents an earnest attempt by staff to balance public health and environmental protection with aesthetic expectations for public and private landscape management. The Council’s review of this document and subsequent public input will allow further refinement to create an ordinance that best reflects the overall intent and interests of the community.

Purpose

The purpose of this article is to safeguard the health and welfare of the residents of the City of South Portland and to conserve and protect the City's water and natural resources. South Portland strives to make organic pest management the primary management tool in our community so that synthetic pesticide use and its damaging effects on the health and welfare of residents and the environment are significantly curtailed.

Findings

WHEREAS, The State of Maine is one of only 7 states, and the District of Columbia, that uphold the rights of localities to restrict pesticides, and this should be seen as an opportunity to affect positive change;

WHEREAS, the EPA, the Committee on Environmental Health of the American Academy of Pediatrics, the National Academy of Sciences, and the 2010 President's Cancer Panel have all concluded that pesticide exposure is linked to reproductive disorders, birth defects, learning disabilities, neurological disease, endocrine disorders, and cancer;

WHEREAS, the EPA acknowledges, along with esteemed Mt. Sinai Children's Environmental Health Center, that children, with their developing bodies and brains, are especially vulnerable to the harmful effects of lawn and garden pesticides. Children's behavior (hand to mouth interactions, proximity to the ground, walking or running through lawns instead of paved sidewalks, especially where there are none), dispose children to far more contact with lawn pesticides than adults;

WHEREAS, pesticides are harmful to pets, wildlife including threatened and endangered species, soil microbiology, plants, and natural ecosystems;

WHEREAS, the City of South Portland has five streams designated by the Maine Department of Environmental Protection (MEDEP) as "urban impaired" for failing to meet state water quality standards primarily due to adverse impacts from surrounding development. All of these streams drain to Casco Bay, which is widely recognized as a natural asset of significant ecological and economic value. The Bay faces long-term threats from stormwater runoff and the use of pesticides has the potential to exacerbate these threats;

WHEREAS, the use of hazardous pesticides is not necessary to create and maintain green lawns and landscapes given the availability of viable non-toxic alternative practices and products;

WHEREAS, people have a right not to be involuntarily exposed to pesticides in the air, water or soil that inevitably result from chemical drift and contaminated runoff;

WHEREAS, recognizing that if an emergency public health situation warrants the use of pesticides, which would otherwise not be permitted under this ordinance, the Pest Management Advisory Committee shall have the authority to grant a temporary waiver on a case-by-case basis after an evaluation of all alternative methods and materials.

WHEREAS, numerous communities and municipalities are embracing a precautionary approach to the use of toxic pesticides in order to adequately protect people and the environment from pesticides' harmful effects.

Definitions

The following words, terms and phrases, when used in this ordinance, shall have the meanings ascribed to them in this section, except where the context clearly indicates a different meaning:

Commercial Agriculture: involves the production of crops for sale, crops intended for widespread distribution to wholesalers or retail outlets and any non-food crops.

Golf course: an area of land laid out for golf with a series of 9, 18 or more holes. Mini-golf courses are not considered golf courses.

Inert ingredient: Any substance (or group of structurally similar substances if designated by the Environmental Protection Agency), other than an active ingredient, which is intentionally included in a pesticide product, except as provided by EPA 40 CFR §174.3.

Invasive Species: An invasive plant is defined as a plant that is not native to a particular ecosystem, whose introduction does or is likely to cause economic or environmental harm or harm to human health. For purposes of this ordinance, invasive species include those listed by the Maine Bureau of Agriculture, Conservation and Forestry as currently invasive, potentially or probably invasive, and highly likely but not currently invasive.

Natural, organic or "Non-synthetic": A substance that is derived from mineral, plant, or animal matter and does not undergo a synthetic process as defined in section 6502(21) of the Organic Foods Production Act (7 U.S.C. 6502(21)).

Organic pest management: An extension of the principles and practices of organic agriculture to the care of turf and landscape.

Pests: are considered undesirable terrestrial or aquatic plants, insects, fungi, bacteria, viruses, nematodes, rodents, birds, animals, or other micro-organisms (except viruses, bacteria or other micro-organisms on or in living persons or other living animals) declared to be a pest under federal or state laws.

Pesticide: Any substance or mixture of substances intended for preventing, destroying, repelling or mitigating any pest; any substance or mixture of substances intended for use as a plant regulator, defoliant or desiccant. It does not include multicellular biological controls such as mites, nematodes, parasitic wasps, snails or other biological agents not regulated as pesticides by the U.S. Environmental Protection Agency. Herbicides, fungicides, insecticides and rodenticides are considered pesticides.

Pest Management Advisory Committee (PMAC): shall act in an advisory capacity to develop and oversee the ordinance, and advise the City Manager or his/her designee of any problems encountered or amendments required to achieve the full and successful implementation of this article including granting waivers.

Synthetic: a substance that is formulated or manufactured by a chemical process or by a process that chemically changes a substance extracted from naturally occurring sources, except that such term shall not apply to substances created by naturally occurring biological processes.

Provisions

The following provisions shall be applicable to all turf, landscape and outdoor pest management activities conducted within the City of South Portland, on both public and private land.

(a) *Permitted:*

Use or application of natural, organic land care protocols.

All pest control products that can be used on Maine Organic Farmers and Gardeners Association Certified Farms, and/or products certified by the Organic Materials Review Institute and/or the Washington State Dept. of Agriculture and/or permitted by the USDA National Organic Program.

(b) *Prohibited:*

Use or application of synthetic pesticides on City-owned and private property, other than pesticides classified by the US Environmental Protection Agency as exempt materials under 40 CFR 152.25, and those products permitted by the Organic Materials Review Institute and/or the Washington State Dept. of Agriculture.

Exemptions

The following applications are exempt from the provisions of this ordinance:

a. Commercial agriculture;
b. Pet supplies such as shampoos and tick and flea treatments;
c. Disinfectants, germicides, bactericides, and virucides;
d. Insect repellents;
e. Rat and rodent control supplies;
f. Swimming pool supplies;
g. Aerosol products;
h. General use paints, stains and wood preservatives and sealants.

Prohibited pesticides may also be applied for the following purposes:

1. **Health and Safety** – Pesticides can be used to control plants that are poisonous to the touch, such as poison ivy; insects that bite, sting, are venomous or are disease carrying, like mosquitoes; and animals or insects that may cause damage to a structure, such as carpenter ants or termites.

2. **Golf course playing surfaces** – including tees, fairways, greens and roughs are conditionally exempt from this ordinance if the owner or operator of the golf course submits and makes public an annual management plan. The plan shall include: a map or plan of the golf course showing all application areas, all measures taken to minimize use of synthetic pesticides on playing surfaces and their exposure to humans and waterways to date, and how the use of pesticide ingredients will be minimized in the next calendar year. These plans must be made public by posting on the golf course's website and a copy provided to the Pest Management Advisory Committee. Non-playing areas associated with golf courses such as lawns, driveways, paths, patios, trees, shrubs, ornamental plantings and gardens are <u>not</u> exempt from this ordinance.

Waivers

In cases that threaten the public health and safety by creating a hazardous situation, and for the control of invasive species that pose a threat to the environment, individuals and/or companies may apply for a waiver from the provisions of this ordinance.

A waiver application is a public record, stating the proposed location(s) and timing(s) of use, substance(s) and amounts to be applied, the date(s) of application, and the reason for requesting use of a synthetic pesticide. The Pest Management Advisory Committee shall decide whether to issue a waiver, and for what duration.

The Pest Management Advisory Committee must find all three (3) of the following conditions to exist in order to approve a waiver for the application of a prohibited pesticide:

(1) That natural and organic methods have proven unsuccessful;

(2) The application of pesticides will not occur within two hundred and fifty (250) feet of a tributary, creek, stream, river, lake, or drainage ditch;

(3) That the granting of the waiver will not result in material damage to other properties in the vicinity, nor be detrimental to the public health, safety or welfare;

Public Notifications and Signs

If prohibited pesticides are applied through an exemption or waiver, the following posting requirements are to be followed. These requirements are in addition to licensed applicators complying with the Maine Board of Pesticide Control rules regarding public notification:

1. Whenever pesticides are to be applied to any land subject to this ordinance, the responsible individuals and/or companies shall post warning signs that meet the requirements of this ordinance. These signs must be posted before application activities commence and left in place for at least 48 hours after actual application or until expiration of the restricted entry interval or reentry time indicated by the pesticide label, whichever is longer.

2. All signs shall be at least five inches high and four inches wide in size. Signs shall be attached to the upper portion of a dowel or other supporting device so that the bottom of the sign is not less than 12" and the top of the sign is not more than 48" above the ground. The signs shall be of rigid, weather resistant material substantial enough to be easily read for at least 48 hours when placed outdoors.

3. All notification signs must be light colored (white, beige, yellow or pink) with dark, bold letters (black, blue or green). They shall have lettering that is conspicuous and clearly legible.

4. The sign must bear the following state requirements:
    a. The word "CAUTION" in 72 point type;
    b. The words "PESTICIDE APPLICATION" in 30 point type or larger;
    c. The Maine Board of Pesticides Control designated symbol;
    d. Any reentry precautions from the pesticide labeling;
    e. The name and telephone number of the entity making the pesticide application;
    f. The date and time of the application;

g. A date and/or time to remove the sign.

5. All notification signs shall state the chemical and trade name of the pesticide, the date to be applied, the length of time to remain off the treated area as indicated by the pesticide label, and a phone number of the responsible party for more information.

Reporting

In addition to complying with the Maine Board of Pesticide Control rules regarding record keeping and reporting requirements outlined in Chapter 50, all licensed applicators are required to submit to the City of South Portland an annual summary report. The report shall contain the following information for EACH application in the City of South Portland: date of application, street address, site and size of area treated, quantity and type of synthetic pesticide and diluents applied, EPA#, application method, total undiluted pesticide, and an explanation of any differences in pesticide use or quantity used from the previous annual report submitted.

Reports shall be submitted to the City Clerk's office by December 31 of each year.

Phase In

Phase One: Effective (Date - 1yr) Prohibits the use or application of pesticides on City-owned property, other than pesticides classified by the US Environmental Protection Agency as exempt materials under 40 CFR 152.25, and those products permitted by the Organic Materials Review Institute.

Phase Two: Effective (Date - 2yrs) Prohibits the use or application of pesticides on private property. It shall be illegal to apply pesticides on private property in the City, whether by the property owner or a tenant, service provider, or other agent. other than pesticides classified by the US Environmental Protection Agency as exempt materials under 40 CFR 152.25, and those products permitted by the Organic Materials Review Institute.

Phase Three: Effective (Date - 3yrs) Conduct an evaluation of this ordinance including a review of pilot project results and reporting data, and provide recommendations for any revisions deemed appropriate.

Outreach and Education

The City Manager or his/her designee shall publish notice of this ordinance and shall provide periodic notice to identified retailers and lawn, garden, and tree-care providers serving South Portland and to churches, schools, and other institutions in the City, upon adoption of this ordinance.

The Pest Management Advisory Committee shall prepare and publish materials designed to educate the community about the role of pesticides in our local environment and the benefits of organic pest management. This outreach should include:

A. A community-based social marketing (CBSM) campaign targeting City households
B. Distribution of information and news about City practices through South Portland internet and web-based resources
C. SPC-TV public service announcements
D. News releases and news events
E. Tax and water bill inserts
F. Posters and brochures made available at City events and applicable locations that serve the public
G. Workshops, trainings, and demonstration projects
H. Targeted outreach to schools
I. Any additional methods deemed appropriate

The Pest Management Advisory Committee shall also develop a program to work directly with retailers who sell synthetic pesticides in the City of South Portland to:

A. Provide educational training for all retail store employees who recommend and sell pesticides for use in the home and garden highlighting
   (a) federal, state, and local pesticide regulations
   (b) principles of organic pest management
   (c) pesticide toxicity & health and environmental concerns
   (d) proper pesticide display and storage
   (e) the role of personal protective equipment, pesticide poisoning symptoms, and emergency procedures in case of spills
B. Implement a toolkit consisting of educational materials and signage (i.e. posters, signs, stickers) that can be customized, printed, and placed in stores to help consumers understand the pesticide ordinance and alternatives to prohibited products/synthetic pesticides.

There are a variety of options for different levels of professional and municipal employee education and training based on the Northeast Organic Farming Association's (NOFA) *Standards for Organic Land Care*, which extends the principles of organic agriculture to land care practices:

A. Accreditation through a three- to five-day course
B. Certificate course online
C. Trainings & webinars targeting organic management of turf and lawn

Authority

The South Portland City Manager or his/her designee shall oversee the implementation of the synthetic pesticide ordinance. A Pest Management Advisory Committee shall be created to act in an advisory capacity to oversee the ordinance through

(1) Advising the City Manager or his/her designee of any problems encountered or amendments required to achieve the full and successful implementation of this ordinance.
(2) Reviewing and granting waivers when applicable.
(3) Developing and implementing outreach and education as specified in the ordinance.
(4) Reviewing annual data and issuing a summary report annually.
(5) Additional responsibilities as deemed necessary by the City.

The Pest Management Advisory Committee will seek the participation, advice and counsel of experts in the fields of organic turf and landscape management, maintenance of trees and shrubs, and organic pest protocol. Broad community participation, from parents, schools, advocates, and local arboriculture and landscaping businesses, will be encouraged. The committee will work closely with the City's Sustainability Office to develop and implement outreach and education.

The Pest Management Advisory Committee shall include:

1. City Stormwater Coordinator
2. City Parks & Recreation Superintendent or his/her designee
3. Two Maine Board of Pesticide Control-licensed landscape professionals; at least one having experience in organic land care management; appointed by the City Manager or his/her designee.
4. Two resident or taxpayer representatives, at-large; appointed by the City Council.

The Pest Management Advisory Committee shall meet regularly and waivers shall be reviewed at scheduled committee meetings. Waiver applications must be submitted at least two (2) weeks before a scheduled meeting date in order to be reviewed. Minutes shall be kept of all meetings with a copy filed with the City Clerk. An annual report of the data submitted by all licensed applicators and a review of the committee's activities shall be submitted to the City Council in March of each year.

Fines and Enforcement

Any law enforcement or Code Enforcement Officer may issue a municipal complaint ticket or citation for offenses of this section.

A. A first offense of any provision of this ordinance shall warrant a letter of warning.
B. A second offense shall be punishable by a fine of two hundred dollars ($200.00).
C. The third offense shall be punishable by a fine of five hundred dollars ($500.00).

D. Any subsequent offense shall be punishable by a fine of one thousand dollars ($1,000).

TAG Bees , Pesticides , honey bees

Pesticide 'Dumbs Down' Bees, Causes Deficits In Memory And Learning

By Dianne Depra, Tech Times | March 3, 6:03 AM

Honeybees have it tough out there. Researchers have found that the pesticide chlorpyrifos, used for protecting crops against mites and insects, causes memory and learning deficits when ingested, even in minute amounts. (Photo : Courtney Collison | Flickr)

After ingesting minute doses of a pesticide called chlorpyrifos, bees suffered severe deficits in memory and learning, potentially threatening their survival, according to a research from the University of Otago in New Zealand.

For the study, published in the *Journal of Chemical Ecology*, researchers collected bees from 51 hives in 17 locations across Otago in Southern New Zealand, detecting low levels of chlorpyrifos in samples from six of the hives and three of the 17 sites.

The presence of the pesticide was not actually surprising because chlorpyrifos has been found in plant, water and air samples even from areas not sprayed, because of the pesticide's high volatility and great ability to travel distances.

In the lab, the researchers fed other bees with the pesticide at levels similar to what they recorded from the samples and them carry out certain tasks to test learning performance.

Based on their findings, the researchers saw that those bees fed with the pesticide performed worse in odor-learning tasks, recalling odors poorly even when the chlorpyrifos dose was considered to be at a "safe" level. For instance, the dosed bees were not able to respond as intended to odors that have been previously deemed as rewarding.

Elodie Urlacher, the study's lead author, explained that honeybees rely on memory mechanisms to find flower targets. Given the result of the study, it appears that chlorpyrifos is stunting bees' effectiveness as nectar foragers and pollinators.

The researchers also identified the dose threshold for the pesticide that prompts sub-lethal effects involving memory and odor learning, setting it at 50 picograms.

This figure is thousands lower than the lethal dose for pure chlorpyrifos and is at the lower range of pesticide levels detected in bees in collected in the field.

According to Urlacher, the results of their work raise serious questions about pesticide use, highlighting the need to review regulations, now that it has been shown that even non-lethal doses can affect honeybees, which also hint at potential dramatic effects for hives around the world.

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Other researchers involved in the study include: Alison Mercer, Kimberly Hageman, Sue Michelsen-Heath, Christie Lombardi, Freddie-Jeanne Richard, Coraline Rivière, and Coline Monchanin.

Photo: Courtney Collison | Flickr

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First online: 12 February 2016

Measurements of Chlorpyrifos Levels in Forager Bees and Comparison with Levels that Disrupt Honey Bee Odor-Mediated Learning Under Laboratory Conditions

- Elodie Urlacher
- , Coline Monchanin
- , Coraline Rivière
- , Freddie-Jeanne Richard
- , Christie Lombardi
- , Sue Michelsen-Heath
- , Kimberly J. Hageman
- , Alison R. Mercer

Abstract

Chlorpyrifos is an organophosphate pesticide used around the world to protect food crops against insects and mites. Despite guidelines for chlorpyrifos usage, including precautions to protect beneficial insects, such as honeybees from spray drift, this pesticide has been detected in bees in various countries, indicating that exposure still occurs. Here, we examined chlorpyrifos levels in bees collected from 17 locations in Otago, New Zealand, and compared doses of this pesticide that cause sub-lethal effects on learning performance under laboratory conditions with amounts of chlorpyrifos detected in the bees in the field. The pesticide was detected at 17 % of the sites sampled and in 12 % of the colonies examined. Amounts detected ranged from 35 to 286 pg.bee^{-1}, far below the LD_{50} of ~100 ng.bee^{-1}. We detected no adverse effect of chlorpyrifos on aversive learning, but the formation and retrieval of appetitive olfactory memories was severely affected. Chlorpyrifos fed to bees in amounts several orders of magnitude lower than the LD_{50}, and also lower than levels detected in bees, was found to slow appetitive learning and reduce the specificity of memory recall. As learning and memory play a central role in the behavioral ecology and communication of foraging bees, chlorpyrifos, even in sublethal doses, may threaten the success and survival of this important insect pollinator.

Keywords

Chlorpyrifos Honey bee Appetitive learning Memory specificity Field measurements

Concepts found in this article

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Sucrose Responsiveness

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Sting Extension

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Are pesticides changing how bees forage?

New research shows that bees treated with a common pesticide may collect more pollen, but have a harder time learning and remembering flower structures and foraging strategies.

By **Ben Thompson**, Staff | MARCH 15, 2016

A bee lands on a Shungiku blossom at the Chino family farm in Rancho Santa Fe, Calif., in 2013. (Mike Blake/Reuters/File)

The latest research on pesticides' effects on bees and their behavior suggests that widely used chemical insect deterrents could negatively affect bees' relationships with flowers.

A new study published in *Functional Ecology* concluded that neonicotinoid pesticides, which are widely used to protect crops against aphids, grubs, and other insects – cause bees to forage for more pollen from wildflowers than do bees not exposed to the insecticides, but that the bees treated with neonics were less efficient, learned to pollinate differently, and ended up with different floral preferences than the ones left chemical-free.

“Bees rely on learning to locate flowers, track their profitability and work out how best to efficiently extract nectar and pollen,” said the paper's senior author Nigel Raine, a University of Guelph professor and pollination researcher, in a university news release.

“If exposure to low levels of pesticide affects their ability to learn, bees may struggle to collect food and impair the essential pollination services they provide to both crops and wild plants,” Dr. Raine added.

Raine and lead author Dara Stanley decided to test the impact of thiamethoxam on the *Bombus terrestris audax* subspecies of European bumblebees. The scientists chose thiamethoxam, a neonicotinoid, to differentiate their experiment from previous studies, many of which primarily focused on the effects of the widely used neonic, imidacloprid, they said. The duo used thiamethoxam concentrations consistent with “field conditions” observed in wild bee populations, dosing separate bumblebee colonies with solutions of either the typical amount of the neonic or simply sugar water, as a control.

The nearly two-week study concluded with the both the treated and untreated bees being introduced to an outdoor “flight arena” filled with flowering *Lotus corniculatus*, or bird's-foot trefoils, and *Trifolium repens* white clovers. The two European Fabaceae flower types were chosen for their complexity and importance to bumblebees, according to the researchers. The bees were introduced to the flight zone individually, where their foraging patterns and flower manipulation – and by extension, their success at pollination – were recorded by observers who had no knowledge of the insects' treatment groups.

The results showed that the bees exposed to the neonic solution spent more time foraging overall, but less time at each flower and less time learning foraging strategies. The insecticide-treated bees also visited the trefoils nearly 60 percent more often than the control bees while visiting the clovers around 20 percent less. The researchers recorded more data on the bees' foraging habits, concluding that "chronic exposure to field-realistic levels of thiamethoxam altered the interactions between bumblebees and morphologically complex wildflowers."

"Our results suggest that current levels of pesticide exposure could be significantly affecting how bees are interacting with wild plants, and impairing the crucial pollination services they provide that support healthy ecosystem function," Raine said.

The exposed bees "initially foraged faster and collected more pollen," while the clean ones "may be investing more time and energy in learning," according to Mr. Stanley.

The results contrast with those of previous studies involving imidacloprid, which found that bees treated with that neonic brought back less pollen less often. But thiamethoxam's impact on the insects' learning and foraging process, especially under "challenging conditions in a wild, fully-outdoor setting," could augment the learning issues and negatively impact the bees' "delivery of pollination services" as well as potentially contribute to worldwide bumblebee population problems.

"Our findings have important implications for society and the economy as pollinating insects are vital to support agriculture and wild plant biodiversity," Stanley said.

Functional Ecology

British Ecological Society

Functional Ecology 2016 doi: 10.1111/1365-2435.12644

Chronic exposure to a neonicotinoid pesticide alters the interactions between bumblebees and wild plants

Dara A. Stanley*,[1,2] and Nigel E. Raine[1,3]

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Summary

1. Insect pollinators are essential for both the production of a large proportion of world crops and the health of natural ecosystems. As important pollinators, bumblebees must learn to forage on flowers to feed both themselves and provision their colonies.

2. Increased use of pesticides has caused concern over sublethal effects on bees, such as impacts on reproduction or learning ability. However, little is known about how sublethal exposure to field-realistic levels of pesticide might affect the ability of bees to visit and manipulate flowers.

3. We observed the behaviour of individual bumblebees from colonies chronically exposed to a neonicotinoid pesticide (10 ppb thiamethoxam) or control solutions foraging for the first time on an array of morphologically complex wildflowers (*Lotus corniculatus* and *Trifolium repens*) in an outdoor flight arena.

4. We found that more bees released from pesticide-treated colonies became foragers, and that they visited more *L. corniculatus* flowers than controls. Interestingly, bees exposed to pesticide collected pollen more often than controls, but control bees learnt to handle flowers efficiently after fewer learning visits than bees exposed to pesticide. There were also different initial floral preferences of our treatment groups; control bees visited a higher proportion of *T. repens* flowers, and bees exposed to pesticide were more likely to choose *L. corniculatus* on their first visit.

5. Our results suggest that the foraging behaviour of bumblebees on real flowers can be altered by sublethal exposure to field-realistic levels of pesticide. This has implications for the foraging success and persistence of bumblebee colonies, but perhaps more importantly for the interactions between wild plants and flower-visiting insects and ability of bees to deliver the crucial pollination services to plants necessary for ecosystem functioning.

Key-words: bumble bee *Bombus terrestris*, ecotoxicology, flower visitation, foraging behaviour, insecticide, pollen, pollinator declines

Introduction

Bumblebees are important pollinators of both crops and wild plants (Stanley & Stout 2014; Kleijn *et al.* 2015). They forage in the environment to collect nectar and pollen, both to feed themselves but also to provision their colonies and feed their developing brood. An individual worker will continue to forage even when they themselves are satiated, and can forage throughout their entire lifetime (Hagbery & Nieh 2012). In order to forage effectively, bees must be able to learn to locate flowers, assess their profitability and how to manipulate them to extract their rewards. As flowers vary hugely in their salient features for pollinators (including their colour, scent and morphology), there is considerable variation in the range of cues bees must detect and learn. As a result, foraging can be a cognitively challenging task, and foraging on complex flowers is typically more challenging than on simple ones (Laverty 1994). In addition, bees may forage for nectar, pollen or both, and it has been suggested that foraging for pollen can be a more challenging task than foraging for nectar (Raine & Chittka 2007b).

In recent years, declines in bumblebees (Grixti *et al.* 2009; Cameron *et al.* 2011; Dupont, Damgaard & Simonsen 2011) and other pollinators (Biesmeijer *et al.* 2006; Ollerton *et al.* 2014) have led to concern over the use of pesticides in agriculture. Bees can become exposed to pesticides while foraging on treated crops or in treated areas,

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but typically are exposed at levels that are not lethal. This has resulted in an increasing body of research on the sublethal impacts of pesticides on bees, and a moratorium on the use of three neonicotinoid pesticides as seed treatments for crops attractive to bees in the EU (Regulation (EU) No 485/2013). Neonicotinoids are widely used worldwide and have received much attention in terms of bees due to the risk they pose in comparison to other pesticides (Sanchez-Bayo & Goka 2014). In addition, they are commonly applied as seed treatments to flowering crops that results in oral exposure of bees foraging on contaminated nectar and pollen. Neonicotinoids are agonists of the nicotinic acetylcholine receptors (nAChRs) and can cause neuronal deactivation in the mushroom bodies of honeybee brains by overexcitation following blocking (Palmer *et al*. 2013; Moffat *et al*. 2015). As the mushroom bodies are linked with both learning and memory (Zars 2000; Menzel 2012), it is unsurprising that impacts of pesticides on learning ability have been established in both honeybees (Decourtye *et al*. 2004a,b, 2005; Williamson, Baker & Wright 2013; Williamson & Wright 2013) and bumblebees (Stanley, Smith & Raine 2015). In addition to direct effects on learning and memory ability, a range of sublethal effects of pesticide exposure on bees have been identified such as impacts on foraging (Gill, Ramos-Rodriguez & Raine 2012; Schneider *et al*. 2012; Feltham, Park & Goulson 2014; Gill & Raine 2014), navigation (Vandame *et al*. 1995; Fischer *et al*. 2014) and reproduction (Gill, Ramos-Rodriguez & Raine 2012; Whitehorn *et al*. 2012; Rundlöf *et al*. 2015).

However, there is an increasing call to make research on pesticides and bees more 'field-realistic', using measurements from field trials or experiments as close to field conditions as possible. With this in mind, semi-field experiments have shown that the impacts of pesticides on learning ability measured in the lab seem to translate into impacts on bee foraging ability in the field. Using RFID technology to measure when bumblebees enter and leave their colony, it has been shown that bees exposed to neonicotinoid pesticides bring back smaller pollen loads or pollen less often, and also behave differently in terms of the amount of time spent foraging (Gill, Ramos-Rodriguez & Raine 2012; Feltham, Park & Goulson 2014; Gill & Raine 2014). Although this evidence suggests that pesticide exposure can alter the ability of bees to forage and manipulate flowers, direct observations of flower-visiting behaviour are lacking. Whilst it has been shown that pesticide exposure can alter flower visitation patterns to apples, a commercial crop with simple floral morphology (Stanley *et al*. 2015), it is not known whether this may also be the case for wild plants with more complex floral morphology.

Here, we investigated whether pesticide exposure can cause changes in the ability of bumblebees to learn how to manipulate and forage from morphologically complex flowers (Laverty 1994). To do this, we allowed naive individual bumblebees (from colonies pre-exposed chronically to either pesticide or control solutions) access from their colony to a flight arena provisioned with complex flowers of *Lotus corniculatus* L. (bird's foot trefoil) and *Trifolium repens* L. (white clover; Fig. 1), both species commonly encountered by bumblebees in agricultural areas (Carvell *et al*. 2006). We then recorded their flower visitation and foraging behaviour.

Materials and methods

Lotus corniculatus and *T. repens* were obtained as plant plugs (from British Wild Flower Plants, Fig. 1), and potted into larger pots in March 2014. Ten colonies of *Bombus terrestris audax* were obtained from Biobest (Westerlo, Belgium) in the middle of June, with a queen and an average of 109 workers (range 87–127). On arrival, colonies were transferred to bipartite wooden nest boxes ($28 \times 16 \times 11$ cm); the brood in the rear chamber, and the front chamber was used for feeding. The 10 colonies were ranked in terms of number of workers and split into five pairs (blocks), and treatment was randomly assigned within block.

We chose to investigate impacts of the neonicotinoid pesticide thiamethoxam, which was the most widely applied neonicotinoid pesticide on oilseed rape crops in the UK in 2012 (Garthwaite *et al*. 2012), on foraging behaviour. Most studies on the potential effects of neonicotinoids on bees have investigated impacts of another compound, imidacloprid (Decourtye *et al*. 2004a; Laycock *et al*. 2012; Bryden *et al*. 2013; Gill & Raine 2014). However, it has been suggested that impacts of neonicotinoid pesticides may not be the same (Goulson 2013), and that in particular thiamethoxam may be less toxic to bees than imidacloprid (Iwasa *et al*. 2004; Mommaerts *et al*. 2010; Blacquière *et al*. 2012; Laycock *et al*. 2014). A solution of 10 parts per billion (ppb) thiamethoxam was prepared by dissolving 10 mg thiamethoxam (Sigma Aldrich) in 100 mL acetone, then 10 μL of this stock solution was added to 1 L of 40% sucrose solution (these calculations are carried out on a v/v basis; on a w/w basis this would give a solution of 8·5 ppb thiamethoxam). The same process was repeated using 10 μL acetone only to produce an equivalent control solution. Solutions were stored in a dark refrigerator for up to 7 days, after which a new batch was prepared to ensure consistent pesticide concentrations. We chose to use 10 ppb thiamethoxam as this falls within the range of neonicotinoid concentrations measured in plant residues under field conditions (Castle *et al*. 2005; Dively & Kamel 2012; Stoner & Eitzer 2012; Godfray *et al*. 2014, 2015; Stewart *et al*. 2014; Botías *et al*. 2015; Rundlöf *et al*. 2015) and is comparable to previous work (Gill, Ramos-Rodriguez & Raine 2012; Laycock *et al*. 2012, 2014; Stanley *et al*. 2015). Every 2 days, a new colony pair began treatment with either 10 ppb thiamethoxam in sugar water or control sugar water (prepared as explained above), to minimize potential for intercolony variation in duration of the pesticide exposure. Colonies were fed both their treatment sucrose solution and untreated commercial honeybee collected pollen (that had previously been frozen) every 2 days. The majority of sugar water was consumed and bees had no alternative food source for a 9–10 day period; therefore any workers tested would have fed on their treatment solution.

Colonies were tested after 9 or 10 days of pesticide exposure. This length of time was chosen to mimic a situation where bees fed on oilseed rape and/or contaminated wild plants exclusively during peak flowering period of the crop. Prior to testing, each colony was allowed access to a gravity feeder (containing their treatment solution) in a flight arena ($60 \times 35 \times 100$ cm) to encourage foraging behaviour for 48 h. On the day of testing, each block was connected to a large flight arena

Fig. 1. Complex morphology of *Lotus corniculatus* (bird's foot trefoil; left) and *Trifolium repens* (white clover; right; being visited by the large carder bee, *Bombus muscorum*). Photos by DAS.

(78 × 52 × 100 cm) in a bright but shaded outdoor location. Flight arenas were provisioned with two flowering *L. corniculatus* plants (with an average of 131 florets across both plants per day) and one flowering *T. repens* (average 11 flowering inflorescences per day; the term flower will subsequently be used to signify *L. corniculatus* florets and *T. repens* inflorescences). These species were chosen as they are known to be important forage plants for bumblebees (Carvell *et al.* 2006), and their flowers have complex morphology (Fig. 1) making them relatively difficult for bumblebees to learn how to handle to extract nectar and pollen. The number of flowers provided by each species was standardized across pairs so each colony in the pair (block) was exposed to the same floral density on each day.

Bees were allowed to enter the flight arena one at a time and the foraging behaviour of each bee was recorded individually by an observer (DAS or DW) using Etholog software (Ottoni 2011). This allowed us to record the number of flowers of each species visited, the time taken to handle each flower, whether individuals collected pollen (or not) and the size of pollen loads (classified as either 'small', 'medium' or 'large'). We also judged when a bee had properly 'learnt' to manipulate a flower (i.e. when a bee landed on a flower and immediately collected nectar and/or pollen, without exploring the flower first; this was not recorded for all bees as in some cases the transition was not obvious). Each bee was observed for 30 min or until it tried to return to the colony, whichever was sooner. At the end of each observation period, tested individuals were placed into a plastic vial and frozen for subsequent measurement of body size. Individuals that did not visit any flowers within 20 min were assumed not to be foragers and removed, and the next bee released. A 10-min break was taken between testing foragers to allow dissipation of any scent marks and replenishment of nectar in the flowers (Stout, Goulson & Allen 1998). Each colony was observed for 2 days, and plants were changed each day. The treatment of the colony observed was unknown by one of the observers, although the other was aware of treatment as they were also responsible for managing and feeding colonies in the lab. Observations were carried out from 23 June until 3 July, between 1030 and 1600. After the experimental period, we measured the thorax width (as a proxy for body size) of all tested bees using digital callipers.

A number of measures of behaviour were extracted from the Etholog data sets: (i) the length of time spent foraging (the time elapsed between the first and last flower visit); (ii) the average length of time between flower visits; (iii) the average visit length to each flower species; (iv) the amount of time it took each bee to learn proper foraging behaviour (as defined above; when a bee immediately went for nectar and/or pollen rather than exploring the flower first); (v) the total number of flowers of each species visited separately; (vi) the number of switches between flower species; (vii) the number of flowers visited before proper foraging behaviour was learnt; (viii) whether bees visited *L. corniculatus* or *T. repens* first; (ix) the proportion of visits to *T. repens* and (x) the proportion of bees that foraged for pollen. We investigated treatment (pesticide-exposed vs. control) differences in these behavioural measures of foragers using linear mixed effects models in R (R Development Core Team 2011). We used the lme function from the nlme package for models in which time was the response variable (Pinheiro *et al.* 2012), the glmer function from the lme4 package for any response variables that were counts or proportions (with poisson or binomial distributions specified: (Bates *et al.* 2014)), and the glmmPQL function from the MASS package for any models where data were overdispersed (Venables & Ripley 2002). To account for any differences in behaviour caused by weather conditions or other interdiurnal differences, date of testing (nested within block) was included as a random effect. The body size of bees was included as a covariate, and models were simplified by removing this term if it was not significant. Models were validated by inspecting qq-plots and histograms of residuals, and plotting standardized residuals vs. fitted values, and data were transformed (log X+1) if necessary to improve model fit.

Results

In total, 160 bees were observed leaving their colonies to enter the flight arena (average 15 per colony from pesticide colonies, and 17 per colony from control colonies; no difference in numbers of bees released between treatments, quasipoisson glm: $F_{1,8} = 4{\cdot}14$, $P = 0{\cdot}08$) of which 74 bees (46%) were classed as 'foragers' (we classified a bee as a forager if it landed on five or more flowers during its time in the arena). A significantly greater number of bees active in the flight arena were foragers in pesticide-treated colonies (63% of bees per colony for pesticide-treated, 33% per colony for control colonies; glmer: $\chi^2 = 4{\cdot}9044$, $P = 0{\cdot}03$), but worker body size did not differ between treatments (GLM: $F_{1,68} = 0{\cdot}0277$, $P = 0{\cdot}87$).

There was no difference between treatments in terms of how long bees spent foraging (Table 1), how long they took to handle either species of flower, or the amount of time spent between flower visits (Table 1). Interestingly, although bees exposed to pesticide learnt to manipulate flowers earlier on in their time in the foraging arena,

Table 1. Summary of variables measured in observations of individuals from pesticide colonies and control colonies. n = 47 foragers from five pesticide colonies, and 27 foragers from five control colonies (except for 'time taken to for foraging behaviour to be learnt' and 'number of flowers visited before foraging behaviour was learnt' where n = 22 foragers from four pesticide colonies, and 11 foragers from four control colonies)

	Mean ± SEM		Model	
Variable	Control	10 ppb	Treatment	Width
Length of time spent foraging	850·79 ± 81·07	940·09 ± 89·38	χ^2 = 0·76, P = 0·38	χ^2 = 2·68, P = 0·10
Length of time spent between flower visits†	35·51 ± 5·24	31·55 ± 5·26	χ^2 = 1·31, P = 0·25	
Mean visit length to *L. corniculatus*	7·52 ± 1·06	6·9 ± 0·66	χ^2 = 0·1, P = 0·76	
Mean visit length to *T. repens*	27·77 ± 4·44	23·82 ± 3·56	χ^2 = 0·18, P = 0·67	
Time until foraging behaviour was learnt†	815·21 ± 107·91	549·35 ± 78·77	$\boldsymbol{\chi^2}$ **= 4·32, *P* = 0·04***	
No. of visits to *L. corniculatus*†	15·81 ± 5·84	38·02 ± 7·62	$\boldsymbol{\chi^2}$ **= 9·8, *P* = 0·002***	
No. of visits to *T. repens*†	7·52 ± 1·71	5·87 ± 1·64	χ^2 = 0·07, P = 0·79	χ^2 = 0·47, P = 0·49
No. of switches between flower varieties†	1·1 ± 0·28	1·7 ± 0·46	χ^2 = 0·85, P = 0·36	χ^2 = 2·90, P = 0·09
No. flowers visited before foraging behaviour learnt	3·7 ± 1·06	9·6 ± 1·8	$\boldsymbol{\chi^2}$ **= 7·3, *P* = 0·007***	
Proportion of bees that visited *L. corniculatus* first	0·52	0·81	$\boldsymbol{\chi^2}$ **= 6·54, *P* = 0·01***	
Proportion of visits to *T. repens*	0·46	0·21	$\boldsymbol{\chi^2}$ **= 6·24, *P* = 0·01***	
Proportion of bees that foraged for pollen	0·15	0·39	$\boldsymbol{\chi^2}$ **= 4·53, *P* = 0·03***	

All times given are in seconds. Values given are means (± S.E.M.) across all individuals released.
*indicates significant differences (P < 0.05).
†Indicates data were transformed for analysis.

control bees learnt how to manipulate flowers after fewer learning visits than bees exposed to pesticide (Table 1, Fig. 2). Most bees foraged only for nectar, with only 23 of 73 individuals collecting pollen. We found that significantly more bees exposed to pesticide foraged for pollen than control bees (Table 1). All seven of the bees classified as carrying 'medium' sized pollen loads were from pesticide-exposed colonies, while the 15 bees with 'small' loads came from both treatment groups (11 pesticide and four control bees).

Bees exposed to pesticide visited more *L. corniculatus* flowers than control bees (Table 1, Fig. 2, Table S1, Supporting information), although there was no difference in the number of *T. repens* flowers visited between treatment groups; however, this meant that a higher proportion of visits by control bees were to *T. repens*. Interestingly, there was a trend towards a preference of pesticide-exposed bees to visit a *L. corniculatus* flower first rather than a *T. repens* (13 of 27 control bees (48%) first landed on *T. repens*, whereas only 9 of 47 pesticide-exposed bees (19%) chose *T. repens* first; Table S1), although this was not significant. There was no difference in the frequency with which bees from each treatment switched between flower species (Table 1).

Discussion

We found that chronic exposure to field-realistic levels of thiamethoxam altered the interactions between bumblebees and morphologically complex wildflowers. First, a higher proportion of bees that were released from pesticide-treated colonies became foragers in comparison to control colonies. Of these foragers, bees exposed to pesticide visited more *L. corniculatus* flowers, showed a trend towards a preference for this species on their first flower visit and collected more pollen. However, although bees exposed to pesticide learnt to manipulate flowers sooner, control bees learnt to manipulate flowers after fewer flower visits than pesticide-exposed bees, and also visited a higher proportion of *T. repens* flowers.

Interestingly, we see increased activity in bees exposed to pesticide in terms of the numbers of *L. corniculatus* flowers visited. This is similar to work showing bees visit a higher number of apple flowers when exposed to field-realistic thiamethoxam levels (Stanley *et al.* 2015), a result that may be indicative of hormesis; a stimulation of biological processes at low doses (Cutler & Rix 2015). Other putative hormetic effects have been found following exposure to other neonicotinoids: imidacloprid, in combination with the acaricide coumaphos, can cause modest improvement in honeybee learning and memory (Williamson, Baker & Wright 2013) and exposure to low-levels of clothianadin can lead to improved orientation behaviour in moths (Rabhi *et al.* 2014). However, although individual bees visited more flowers in the Stanley *et al.* (2015) study, the pollination services provided were not affected suggesting that this increased activity did not deliver improved pollination quality.

Previous studies of colonies foraging freely outside in the field have found that bees exposed to imdacloprid bring back pollen less often (Feltham, Park & Goulson 2014) and/or bring back smaller pollen loads (Gill, Ramos-Rodriguez & Raine 2012). Here, we find bees exposed to similar levels of thiamethoxam actually bring back pollen more often than controls. This may be related to the decreased amount of time spent learning how to manipulate flowers, allowing pesticide-exposed bees more time to collect pollen (see additional discussion of speed-

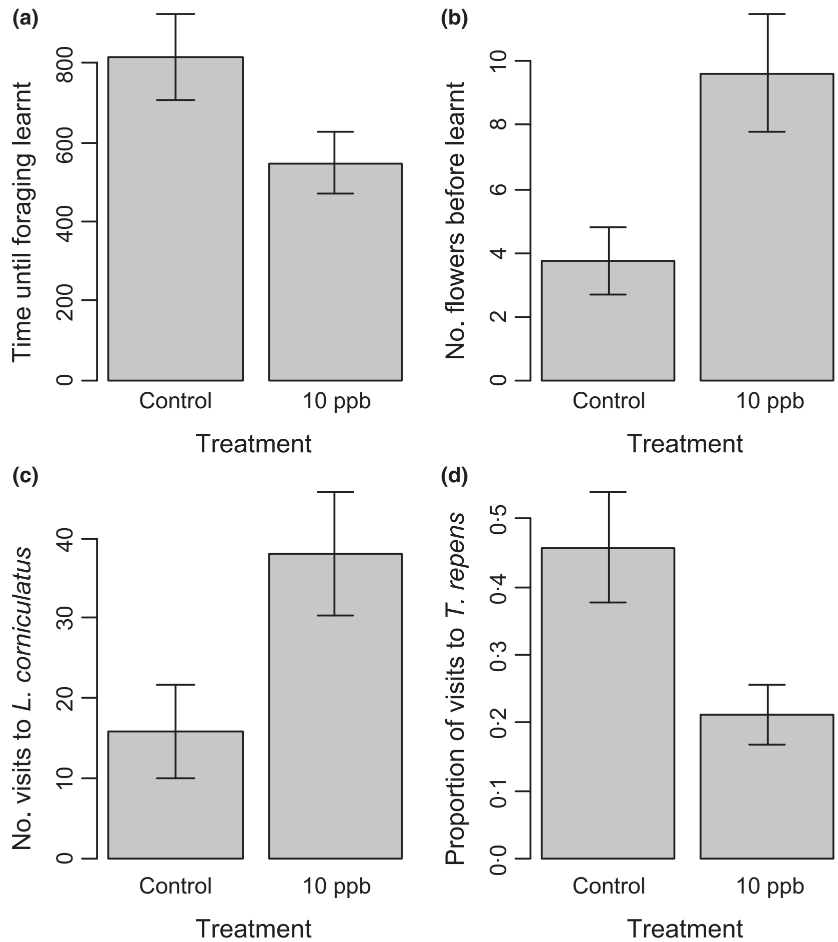

Fig. 2. The differences in (a); top left time until foraging behaviour was learnt, (b); top right number of flowers visited before the individual bee learnt to properly manipulate the flower, (c); bottom left number of visits to *Lotus corniculatus* and (d); bottom right proportion of visits to *Trifolium repens*, for individual bees exposed to control (untreated) or 10 ppb thiamethoxam treatments. Columns show means (±SEM) across all foragers observed (47 individuals from 10 ppb colonies, 27 individuals from control colonies for number and proportion of visits to species, and 22 individuals from 10 ppb colonies and 11 from control colonies for time and number of flowers until foraging behaviour learnt). There was a significant difference ($P < 0{\cdot}05$) between treatments for all variables displayed (Table 1)

accuracy trade-offs below). However, this pattern may change over time, as bees exposed to imidacloprid have been shown not to improve their foraging ability over time – unlike, unexposed, control bees (Gill & Raine 2014). In addition, our data were collected in an outdoor flight arena in which bees had to fly less than 50 cm to access their first flower, representing a relatively simple environment with little need to navigate, locate forage resources or avoid predators. Previous studies were carried out in a natural, outdoor setting (Gill, Ramos-Rodriguez & Raine 2012; Feltham, Park & Goulson 2014), with bees facing a much more challenging environment in terms of navigation and location of floral resources. This could indicate that impairments in foraging ability following pesticide exposure may not be due to patterns of flower visitation, but the ability of bees to deal with variation in weather conditions, landscape-scale navigational complexity or indeed responses to additional stressors in the environment.

Although pesticide-exposed bees collected pollen more often and visited more flowers overall, we found that control bees visited fewer flowers before manipulation behaviour was learnt. As bumblebees display trade-offs between the speed and accuracy with which they make foraging decisions (Chittka *et al.* 2003; Ings & Chittka 2008; Chittka, Skorupski & Raine 2009), and exposure to pesticides can affect learning and memory performance in bumblebees (Stanley, Smith & Raine 2015), it is also possible such exposure could affect speed-accuracy trade-offs. Bees exposed to pesticide initially forage faster and collect more pollen as control bees might be investing more time and/or energy in learning. It can take up to 30 foraging trips for an individual bee to reach maximum foraging efficiency (Peat & Goulson 2005), and the average handling times for *L. corniculatus* measured here on a first foraging bout are higher than those measured for experienced bees in the field (Stout & Goulson 2002). Therefore as we only observed the first foraging trip, control bees had not yet fully learnt how to forage to the best of their ability, and so may not yet have been 'accurate' foragers. This view is supported by previous work showing that bees exposed to (imidacloprid) pesticide do not improve their pollen collection performance over time but un-exposed bees do (Gill & Raine 2014).

We found a difference in floral preferences between our treatment groups; pesticide-exposed bees exposed visited more *L. corniculatus* flowers and were more likely to visit this species first, but control bees visited a higher proportion of *T. repens* flowers. Previous work has also found differences in the colour of pollen loads collected by imidacloprid-exposed bees compared with untreated controls (Gill & Raine 2014), suggesting impacts of pesticides on floral preference. A mechanism for this could be detrimental impacts of pesticide on cognition (Stanley, Smith & Raine 2015), particularly the ability to learn to manipulate a greater number of flower types - a task known to be more cognitively challenging (Gegear & Laverty 1995, 1998). *Lotus corniculatus* and *T. repens* differ in colour, morphology (Fig. 1) and quantity of rewards (with *L. corniculatus* producing more nectar than *T. repens*; Raine & Chittka 2007a), all of which may affect how bees learn to manipulate them. However, *T. repens* is a more nutritious forage source than *L. corniculatus* with twice the total sugar content and higher concentrations of amino acids (E. Power, personal communication). The nutritive quality of floral resources can influence bee foraging behaviour (Somme *et al.* 2015); therefore another mechanism could be that pesticide may influence a bee's ability to choose forage resources based on nutritive content (although bees cannot taste neonicotinoids Kessler *et al.* 2015). These changes in floral preference may be the cause of differences seen in other measures in our study, such as length of time spent foraging. However, to fully disentangle these effects of species choice and arrangement, bees would have to be presented with both species singly and as mixtures which would be a useful follow-on experiment from this study.

Although, to our knowledge, this study is the first to investigate impacts of pesticides on foraging behaviour of bees on real wildflowers, some previous studies have investigated similar impacts using artificial food sources in the laboratory. Using RFID technology in a flight arena, honeybees exposed to imidacloprid and clothianadin showed a reduction of foraging activity and longer foraging bouts when exposed to high pesticide concentrations, although with no impact seen at field-realistic levels. (Schneider *et al.* 2012). Morandin & Winston (2003) found that bumblebees (*Bombus impatiens*) exposed to 7 ppb imidacloprid in pollen had a similar foraging rate to untreated controls, but that bees exposed to higher levels (30 ppb) had a significantly lower foraging rate. Using comparable doses of another neonicotinoid, clothianadin, Franklin, Winston & Morandin (2004) found no difference in times taken by pesticide-treated and control bees to access rewards from artificial flowers in a foraging arena after 48 days of exposure, although there was a trend towards lower mean access times for bees exposed to 6 ppb and 36 ppb. However, it is likely that visitation to real flowers with complex morphology represents a significantly more challenging task to bees than foraging on simple artificial flowers, and our work suggests that under these conditions impacts on foraging behaviour may be more apparent.

Changes in foraging behaviour resulting from pesticide exposure are interesting from the 'bee' perspective as it introduces the potential to alter colony provisioning that places additional stress on the colony with implications for colony survival (Bryden *et al.* 2013). However, bees provide essential pollination services to crops and wild plants (Klein *et al.* 2007; Ollerton, Winfree & Tarrant 2011), and as such changes in foraging behaviour may have knock-on impacts for the pollination services they deliver. Although pesticide exposure has been shown to decrease pollination services delivered to apple crops (Stanley *et al.* 2015), the extent to which this might also be true for wild plants is unclear. An increase in numbers of foragers, thereby making more flower visits and collecting more pollen (and hence transporting more pollen between individual plants), may have positive implications for the delivery of pollen to flowers and therefore seed set. Alternatively, if bees exposed to pesticide take longer to learn to manipulate flowers and show different floral preferences, or scent mark flowers without proper visitation thereby discouraging other bees from visiting them (Stout, Goulson & Allen 1998; Stout & Goulson 2002), this could have negative impacts on pollination service delivery.

The majority of research on the impacts of neonicotinoids on bees to date has focussed on imidacloprid, using honeybees as a model system (Godfray *et al.* 2014, 2015; Lundin *et al.* 2015). Here, we find that field-realistic levels of thiamethoxam can alter foraging behaviour of bumblebees in a relatively simple environment. At similar exposure levels of thiamethoxam, effects on bumblebee reproduction seem to be variable; at 10 ppb nest building was delayed and no larvae were produced (Elston, Thompson & Walters 2013), no detectable effect on reproduction or survival of queenless microcolonies was detected at 11 ppb (Laycock *et al.* 2014) or on male production at 10 ppb (Mommaerts *et al.* 2010). However, following chronic exposure to 10 ppb thiamethoxam bumblebees learn an olfactory conditioning task more slowly than controls and their short term memory can be affected (Stanley, Smith & Raine 2015). This suggests that it could be useful to incorporate other behaviours, such as learning ability and foraging, into pesticide risk assessments that currently use only mortality or reproduction; impacts may be seen on foraging when no impacts on reproduction are detectable (Mommaerts *et al.* 2010).

There are a number of environmental stressors that can cause changes in bee foraging behaviour (e.g. parasites; Schmid-Hempel & Stauffer 1998; Gegear, Otterstatter & Thomson 2005; Otterstatter *et al.* 2005; invasive species; Dohzono *et al.* 2008; predators: Jones & Dornhaus 2011). Our work shows that exposure to field-realistic levels of pesticide stress can also alter foraging behaviour of bumblebees on real wildflowers with complex morphology even in a relatively unchallenging scenario. This suggests that under more challenging conditions in a wild, fully-outdoor setting, impacts may be augmented. As we only looked at the first foraging bout of individuals, it is likely that impacts may also change over the foraging life of the individual. Our work highlights the need to include taxa other than honeybees in risk assessments for pesticide use, and that bumblebees can also be a useful study taxon. It also confirms that changes in foraging behaviour on wildflowers represent another sublethal impact of pesticide use, which may have implications for the delivery of pollination services to wild plants.

Acknowledgements

We would like to thank David Wells for help with bee foraging observations, Elli Leadbeater for the loan of large flight arenas and Karen Smith, Dave Goulson and an anonymous reviewer for useful comments on previous versions of this manuscript. This work was supported by grant BB/I000178/1 of the UK Insect Pollinators Initiative funded jointly by the Living with Environmental Change programme, Biotechnology and Biological Sciences Research Council (BBSRC), Wellcome Trust, Scottish Government, Department for Environment, Food and Rural Affairs (DEFRA) and Natural Environment Research Council (NERC) and NER is supported as the Rebanks Family Chair in Pollinator Conservation by The W. Garfield Weston Foundation.

Author contributions

DAS and NER conceived the project, designed the experiment and wrote the manuscript. DAS carried out the experiment and statistical analyses.

Data accessibility

Data are given in the Supporting Information.

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Received 5 June 2015; accepted 21 January 2016
Handling Editor: Manfred Ayasse

Supporting Information

Additional Supporting information may be found in the online version of this article:

Table S1. Sequences and flower handling times (in seconds) of the first 30 floral choices for all foragers exposed to control (a) or pesticide (10 ppb thiamethoxam) (b) treatments; n = the total number of flowers visited in the foraging bout. Light grey represents visits to *Lotus corniculatus*, and dark grey represents visits to *Trifolium repens*.

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GMO Mosquito Gets Finding of 'No Significant Impact' from FDA

Tue, 03/15/2016 - 9:48am

by Seth Augenstein, Digital Reporter

The world's first self-limiting tropical mosquito, seen as a possible control to the spread of viral diseases such Zika, dengue and yellow fever, is on its way to approval.

The engineered *Aedes Aegypti* male mosquitoes breed with females and produce offspring that do not live to adulthood. The OX513A mosquito, created by UK-based Oxitec, Ltd., is seen as a population control tool to curb the spread of the disease-carrying bug.

The FDA released its preliminary finding of no significant impact on Friday, in the first environmental assessment. The public comment period will last 30 days.

The company said it was "pleased" with the finding.

The *Aedes aegypti* mosquito represents a significant threat to human health, and in many countries has been spreading Zika, dengue and chikungunya viruses," said Hadyn Perry, the Oxitec CEO. "This mosquito is non-native to the U.S. and difficult to control, with the best available methods only able to reduce the population by up to 50 percent, which is simply not enough. We look forward to this proposed trial and the potential to protect people from *Aedes aegypti* and the diseases it spreads."

The Oxitec mosquitoes are males, and do not bite or spread disease. But they do mate with the native female population, resulting in short-lived offspring.

The company claims field trials in the Cayman Islands, Panama and Brazil have resulted in reduction of the insect population by 90 percent.

The Aedes aegypti bug is non-native to the United States – but has spread north to the Florida Keys in recent years. The latest field trial for Oxitec is taking place in Key Haven, Monroe County.

The FDA, in its conclusion, found that the GMO insect was preferable to massive use of insecticides over large areas.

"The impact on the environment and non-target organisms is likely to be less than the use of broad spectrum insecticides for mosquito control," the agency found.

The FDA has approved other genetically-modified species. In November, they issued an approval for a kind of salmon for consumption.

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U.S. Food and Drug Administration
Protecting and Promoting *Your* Health

FDA Announces Comment Period for Draft Environmental Assessment for Genetically Engineered Mosquito

March 11, 2016

The FDA is releasing for public comment a draft environmental assessment (EA) submitted by Oxitec, Ltd., that assesses the potential environmental impacts of a field trial of the company's genetically engineered (GE) *Aedes aegypti* mosquitoes (OX513A) in Key Haven, Florida. *Ae. aegypti* is known to transmit potentially debilitating human viral diseases, including Zika, dengue, yellow fever and chikungunya.

The National Environmental Policy Act (NEPA) requires federal agencies to assess the environmental impacts of certain actions. Pursuant to FDA regulations, sponsors opening an Investigational New Animal Drug (INAD) file must submit either a draft EA or a claim of categorical exclusion from the EA requirement.

The FDA is also releasing a preliminary finding of no significant impact (FONSI) that agrees with the draft EA's conclusion that the field trial of such GE mosquitoes will not result in significant impacts on the environment.

Oxitec will not conduct the field trial of its OX513A mosquito until the FDA has had the opportunity to review public comments on the draft EA, and subsequently has issued either a final EA and FONSI or an environmental impact statement.

The FDA is accepting public comments on the draft EA and preliminary FONSI for 30 days from the date of publication in the Federal Register. To submit your comments electronically to the docket, go to **www.regulations.gov (http://www.regulations.gov)** and type FDA-2014-N-2235 in the search box. While comments are welcome at any time, you should submit them by the closing date to ensure FDA considers your comments.

To submit your comments to the docket by mail, use the following address. Be sure to include docket number FDA-2014-N-2235 on each page of your written comments.

The Division of Dockets Management
HFA-305
Food and Drug Administration
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Additional Information

- **Oxitec Mosquito (/AnimalVeterinary/DevelopmentApprovalProcess/GeneticEngineering/GeneticallyEngineeredAnimals/ucm446529.htm)**
- **Oxitec Mosquito - Draft Environmental Assessment (PDF - 33.3MB) (/downloads/AnimalVeterinary/DevelopmentApprovalProcess/GeneticEngineering/GeneticallyEngineeredAnimals/UCM487377.pdf)**
- **Oxitec Mosquito - Preliminary Finding of No Significant Impact (PDF - 148KB) (/downloads/AnimalVeterinary/DevelopmentApprovalProcess/GeneticEngineering/GeneticallyEngineeredAnimals/UCM487379.pdf)**
- **Notice of Availability; Draft Environmental Assessment and Preliminary Finding of No Significant Impact Concerning**

[Investigational Use of Oxitec OX513A Mosquitoes (https://www.federalregister.gov/articles/2016/03/14/2016-05622/environmental-assessments-availability-etc-investigational-use-of-oxitec-ox513a-mosquitoes)](https://www.federalregister.gov/articles/2016/03/14/2016-05622/environmental-assessments-availability-etc-investigational-use-of-oxitec-ox513a-mosquitoes)

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