TITLE: The World in a Box? Food Security, Edible Insects, and "One World, One Health" Collaboration

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ABSTRACT: Scientists in the Netherlands are cultivating edible insects to address concerns of international food security. Committed to the *One World, One Health* (OWOH) movement, their research aims to create a safe and effective *global* solution to the conjoined problems of climate change and an increasing worldwide demand for protein. Their preliminary work is promising, as it suggests that when compared to other sources of meat, insects can be an efficient, safe, and low-impact source of nutrients. Additionally, in many sites with endemic malnutrition, people find insects tasty. The problem these scientists are grappling with, however, is that insects that are easily mass-produced are not the insects people typically want to eat. This paper shows how the contingency of edibility complicates existing scientific models of travel in which an object spreads peripherally outwards from a center into a globally connected, singular world. The scientists are finding that the production of successful products necessitates that insects be constantly tinkered with, so as to be *made and remade* variously. This in turn complicates the vision of replicability and "scaling up" inherent in an OWOH vision of science. The researchers' process of moving their goods from laboratory boxes into the mealtime practices they seek to impact is compelling them to cultivate and articulate new ideals for research, methods of translation, and pathways by which goods can travel. They are finding that if they want to affect the food supply and health of "the world," they must engage with many different worlds.

Introduction: Science for Impact

The researcher meets me in the lobby of the entomology building, where a sculpture of a giant butterfly peers down on us. Its yellow wings open up, their tips pointing to the motto "*Science for Impact*." I am there to observe the researcher's strategies for addressing food security. His team, based out of Wageningen's Laboratory of Entomology in the Netherlands, received a grant from the Food and Agriculture Organization (FAO) for research in sustainable agriculture. The grant referred to global hunger and climate change. As we pass through the chip-activated glass gates the researcher speaks of international trends in urbanization, a rising worldwide demand for protein, and designs for products that solve global malnutrition. His language is ambitious, his aim expansive.

When we reach his temperature-controlled lab, he unlocks a dark closet at the back of the room and takes out a small brown box in which he is conducting his experiment. Dozens of small mealworms crawl through the soil. He asks me to guess how many are there, and though I guess high, he laughs, telling me there are at least three times that many. Enjoying my disbelief at the interplay of these registers of scale – global hunger materializing in this small box – he proclaims with pride: "Edible insects can feed the world."

Feeding the world is a goal of both this project and the UN organization that granted it funding. The FAO is among many organizations that have recently partnered to address concerns for food security through increased integration. The effort to forge "co-equal, all inclusive collaborations"[i] stems from the holistic idea that uniting a range of perspectives will benefit the greater good. Security is enhanced by "collaborative efforts of multiple disciplines working locally, nationally and globally" to improve *the* health of *the* world (AVMA, 2008). A premise of this collaboration is that health innovation that works in one site should lead to standardized intervention, design, and implementation so as to be easily "scaled up." (Bloom & Ainsworth, 2010; Jarosz, 2011). An expert report on the topic explains: "Scaling up expands, replicates, adapts, and sustains successful policies, programs, or projects to reach a greater number of people" (Linn, 2012). Whether scaling up is implemented as horizontal replication (from one site to another) or vertical replication (from local to national policies) this imagery of replication depicts the smooth, linear distribution of resources from one location to a shared, singular world.

The scientist in the edible insect lab similarly wants the contents of his box to become spread into the world. He tells me that he hopes his work will have effects that will reverberate, "like air moved by butterfly wings," from his lab out to distant peripheries. But just after he says this he pauses to rethink the analogy of butterfly wings. This is not quite right, for unpredictable travel is not what he is after. Instead, driven by concerns for malnutrition and climate change, there are specific outcomes he wants to achieve. He describes a linear outward expansion of his work: the replication of the edibility he is in the process of producing in his lab to far away sites.

Yet as I spend more time studying the research being carried out in the lab, I learn that this model of expansion is not, in fact, working very well. While the edible insect scientists might dream of being able to replicate boxes of edible nutrients (in the form of insects) to the world, the obstacles they encounter in their research suggest that this model for movement is getting in their way. Despite the allure of replication – despite the attractiveness of the concept of *scaling up* to a singular world – they are finding that for edible insects to spread they must be made, and remade, variously. If the box is to travel, it must travel with care, and its attendant interest in difference, nuance, and specificity (cf. Mol et al., 2010). It is a paradox they have begun to recognize and work to engage: to be effective – to impact *the world* – the box must be kept small.

This article seeks to unpack the paradox of *situated travel* the scientists confront in their work on food security, and in so doing, to broaden understandings of global security and global science. Haraway has famously written "Science has been about a search for translation, convertibility, mobility of meanings, and universality—which I call reductionism, when one language (guess whose) must be enforced as the standard for all translations and conversions" (1991). Her overview aptly identifies the reductionist search for universal translation that pervades many contemporary discourses of food security. The *One World, One Health* (OWOH) movement encourages the integration of multiple "stakeholders" and "sectors" in order to strengthen health, which becomes configured through this integration, as a singular thing. This movement underscores the benefit of global unity produced by this collaboration, taking as a foundational principle that "it is imperative to build a common vision" (FAO, 2013). As one British expert who consults for the FAO on matters of food security explained to me, not incidentally in his native tongue, "we can overcome diversity by finding a common language."

Meanwhile, though the edible insect scientist also cares about the conjoined concerns of global, ecological, and animal (which includes, for him, human) health, and though his lab is publicly committed to the OWOH agenda (cf. van Huis et al., 2013:66), he is finding when it comes to global food security, the singularity of a common vision may not be the best approach. For in his work he must not simply concern himself with facts to be unearthed and then multiplied within the box, but with practical problems of how the small box in front of us can become relevant to the appetites and markets of diverse regions. This shifts him from scientific discovery, in which truth is revealed, to scientific cultivation, in which truths (in the plural) must be attended to, cared for, and grown (see also Mol, 2012). The cultivation of his research, in turn, challenges the idea that scientists themselves necessarily see science as something that operates through the universality of fact. As detailed below, when he tries to replicate this box, with its thousands of mealworms, in other places, the replication fails. The box, it turns out, is not so much a microcosm of a possible world, nor a fixed object able to travel the world unchanged, but a shifting technology that has different effects in different places. To impact world food security, the scientists must attend to variation in its structure and contents. They must in turn develop methods for *situated travel* in which objects, to take hold, must be persistently, carefully, renegotiated.

When addressing the development of scientific techniques for bios-security, Latour writes that "It is still possible to follow how sciences are used to transform society and redefine what it is made of and what are its aims" (1983:144). But Latour speaks here of scientists working with microbes, and we (the insect scientists and their ethnographic-observer) are facing different security concerns, as well as different methods of transfer and translation. The scientists in the edible insect lab work in the terrain of eating – with its pleasures of ingestion and adoption of styles – and not with concerns of unwanted spread of infection. The risk they confront is not of an invisible, hidden contagion that might strike in the dark (Latour, 1983:147). The risk in the project of improving food security, rather, lies in the realm of the familiar: that people will persist in doing what they have been doing, going about their business, activities unchanged.

This paper, following a brief methods section, unpacks results from three of the edible insect scientists' research projects. It details how in their efforts to produce 1) products, 2) appetites, and 3) markets the researchers are learning that edibility must be crafted in specific situations—in response to the needs, regulations, and tastes of specific bodies and infrastructures. The subsequent discussion section illustrates how the contingency of edibility complicates a model for scientific impact in which a singular object spreads peripherally outwards in a replicable, determinate fashion. This leads to concluding reflection upon how challenges faced in work on food security might shift the vision and strategies of OWOH.

The OWOH agenda seeks to establish an integrated approach to addressing environmental security through shared global and interdisciplinary solutions to concerns of inter-species problems. But in analyzing the dilemmas faced by edible insects scientists, it becomes obvious that their work pushes up against the foundations of this movement. The challenges of moving nutrients from a laboratory box into “the world” illuminates the shortcomings of the current OWOH focus on singularity and commonality when applied to concerns for food security. The results of the scientists’ research suggest that for any particular initiative to succeed, more than “one world” or one form of health must be incorporated into the research framework. Instead of compress variation into commonality, they are finding variation to be a useful, necessary resource to learn to care for, and live with.

Methods, Para-sitic Ethnography

The methods for this research are adopted, conveniently enough given the topic, from Marcus’ vision of *para-sitic* ethnography. Para-sitic ethnography aims to address the challenge of working through projects and problems with groups with whom there is sometimes (but not always) agreement, using methods that may at times align and other times diverge. In reference to “experiments” conducted at the World Trade Organization, Marcus explains that para-sitic social science enlists collaborations with research counterparts who are themselves involved in reflective consideration about norms of engagement, and, through these collaborations, to creatively examine how ideas central to the political organization of their projects "circulate, have effect, and change" (Deeb & Marcus, 2011:52). Collaboration is here figured as a means of creating novel research approaches in a way that draws from others, without dissolving differences together (see also Serres, 1982).

As the scientists' research unfolds on shifting terrain, so does my own. The group holds meetings, they share ambitions and funding sources, but there is not a singular event or experiment that has already happened upon which I base this article. In accordance with the ethics guidelines of the University of Amsterdam, since March, 2011, I have spent time in their labs; their public meetings including a large outreach program aimed at children and several much-less-public scientific presentations at global health and agricultural conferences; reviewed PowerPoints and edited publications; and formally interviewed eight of the project's participants, including the director. We have eaten together (yes, insects, though not exclusively), watched The Simpsons (an episode on eating insects), and held many lively debates over email as we have ourselves traveled between The Netherlands, Rome, Lao, Central America, Kenya, Malawi and the United States. Still, the work of the researchers I detail here is, like the worlds in which they work, in the making. There is no end to the project of cultivating edibility and as they continue to experiment, I am engaged in experimental work alongside them. This collaboration is, like the research process itself, unchartable territory, an experimental system in Rheinberger's sense where not just the knowledge, but its pathway of assembly, is emergent (1994).

While the scientists' work is an intervention into food security, my work is, in many ways, an intervention into theirs. It is not an intervention in the form of critique, but one meant to bolster and sharpen their aims, to contribute to their concerns, and to aid in the impact(s) of their work. In many ways this article describes what the scientists already know, but by approaching their research with my social scientific skillset, I hope to give additional shape to their findings. (After sending this article to the entomology team, one of the researchers responded, "I must say that it is a very different from what I do, but that there are many elements in there that resonate with me.") In the multi-sectoral, OWOH field of global sciences in which integration and "a common vision" is the rage, the article is an experiment in collaboration (see also Choy et al., 2009; Kelly et al., 2010) that aims to enhance – without ever replicating – their results.

Results I: Local, Temporal Biologies

Mealworms are the staple insect for the scientists in the edible insects lab. They also work with beetle larvae and grasshoppers, but mealworms are the cheapest and easiest to raise, and many of the project's hopes for humanity have been pinned on them. Unlike pigs and cows they produce negligible amounts of methane (Oonincx et al., 2010). They live on relatively little water and per kilogram they have a good deal more protein than beef or pork (Oonincx & de Boer, 2012). The scientists describe them as efficient feed converters, and their research suggests they might provide a more sustainable source of edible animal protein than common livestock. That is, if only people would eat them.

In publications, the scientists identify mealworms taxonomically: *Tenebrio-molitor: Coleoptera; Tenebrionidae*. But no one calls them this in the lab. In the lab, taxonomic classification alone is not useful as it overlooks lifecycle, and, for the purposes of edibility, it is the lifecycle that is crucial. The fat, round beetle – in whom wheat bran and fresh slices of potato have become fibrous wings and a thick black casing – is the same taxonomic insect as the soft supple worm, but its nutrients are no longer bioavailable for humans. So the beetle is the same species as, but also quite different from, the mealworm, which has no skeleton, or sinew, or shells to fill landfills (see figure 1).

The lack of waste in the body of mealworms excites the scientists. “Everything on the mealworm can be popped into the mouth and eaten,” they say proudly. But they will also qualify that edibility is not simply “what goes in the mouth.” To be edible, the insects should also not kill those who eat them. While this may seem obvious, it becomes less so given that metabolism necessarily entails cellular senescence, and that when it comes to the generative processes of metabolism, destruction, killing, and death are not straightforward things. The scientists spend considerable resources testing the insects for poisons and grappling with questions of safety. But even in the controlled environment of their labs, dichotomies between safe and poisonous do not hold. Instead, their research proceeds through the grey areas of shifting boundaries where vitality and illness, potential and risk entangle.

That edibility is not an inherent property of an object is evident in the scientists’ work on allergens. Many insects carry toxins in their bodies that produce dangerous immunological responses when ingested (Verhoeckx et al., 2014). It is only moderately helpful for the scientists that they can study regions in the world where people eat insects without obvious detriment. For even if a particular species is commonly eaten in what they call “the wild” (imagined here as a space far from the lab) these insects have not been factory produced, freeze dried, and sold in bulk. The critters in Amazonian forests develop differently from domesticated insects. They eat different things, live in different soils, and cohabitate with other insects in different ways. As a result, there can be no guarantee of edibility, even when evaluating two specimens of the same taxonomic classification. “Local biologies” (Lock & Kaufert, 2001) make global safety difficult to calibrate.

Temporal biologies also matter. These reflect not just the deep temporality of life cycle metamorphosis but also the stochastic temporality of the insects' daily dietary patterns. Mealworms confront the scientists with concerns of "gut loading"—the practice of feeding a mealworm with particular foods just prior to its death. Eating a mealworm involves not only consumption of the nutrients of its meat and blood; also devoured are entrails and their contents. If the mealworm has not fully metabolized its meal, the consumer will eat feed held inside the mealworm's body. In other words, the eater of the mealworm eats, directly, what the mealworm has eaten.

This literal consumption of embodiment – "eating guts" as one scientist put it – presents the researchers with several challenges related to insect distribution. Some of these pertain to safety protocols, since regulations are often much less strict for feed (what livestock eat) than food (what humans eat). Others pertain to branding, since a mealworm fed wheat-containing meal just before its harvest cannot safely be advertised as gluten-free. Others pertain to challenges of taste, since the eating of gut contents forces scientists to consider not just the flavor of mealworms, but the flavor of what the worms have been eating.

When it comes to ascertaining safety, the concerns the scientists must grapple with proliferate endlessly. Even if it were possible to standardize a species across its life cycle and dietary patterns, variation in the bodies of eaters still must be reckoned with. Many insects will cause no adverse reactions for most people who eat them, and yet the presence of allergens that are reactive for a few people continues to make insects a risky food: what is non-toxic for most, might still be deadly for some. It is also possible that repeated exposure (in the form of either eating or handling) will cause allergic sensitivity to develop, so that a historically benign insect will become so no longer. There is further concern that some insects are associated with toxic metabolites that could have subtle carcinogenic effects—a “reaction” that does not develop instantly but over the human lifespan.

One scientist who concentrates on allergens describes her research as “especially difficult” because it probes so many untested realms. She spends her time searching for unknown chemicals or chemical combinations that will have unknown reactions in unknown quantities over unknown periods of time; she is looking for things she does not and cannot know (Rheinberger, 1994:76). I comment that these are challenging circumstances in which to trace chemical facts. She looks puzzled, as if I have not understood her work, and responds that her time is not spent with “facts” – that is, things that would be everywhere the same – but with protocols. What will be allowed? And how will these regulations be determined given the limited history of commercial production of the products she works with (many of which are not even products yet)?

The scientists must work closely with policy and regulatory agencies. But as with the researchers, the public health bodies that will eventually need to stamp the insects as a “*safe”* consumer good are operating amidst unknowns. Those setting policies must base their decisions on continuums, where there is no absolute safety, not on clean delineations between edible and poison. Recognizing that most foods can be hazardous under certain conditions, they work with the scientists to ask not *is it edible?* But *for whom, when, and where*? That an agency may then certify a product as safe entails a sleight of hand: what might appear to be an intrinsic property of the food is instead contingent upon political decisions, a history of research, and the speculative examinations of a laboratory team.

Results II: Markets Will Open if Mouths Will Open

What is engineered and cultivated in a Dutch laboratory cannot have the desired effects without leaving the lab; the insects must move from their boxes into the mouths, and bodies, of eaters. So, in addition to the various tasks involved in carrying out laboratory experiments – obtaining research permits, slicing carrots, weighing soil, dissecting insect parts, requesting chemical assays, running computer analyses – public outreach is also a part of the scientists' work. They give open lectures about edible insects, meet with school classes, organize campus events and fairs, and talk with journalists (and interested anthropologists too!). Geographer Angela Last, who has studied the emphasis that UK-based edible insect scientists place in public interaction, refers to their techniques of audience engagement as a form of "co-experimentation," in which the public is explicitly enlisted in the roles of "scientific citizen, innovator, and pioneer" (Last, 2013:103). The scientists hold that the success of their experiments depends upon their translation to others outside the laboratory, but one way they go about this is by bringing the public into the lab. This happens metaphorically, through raised awareness about the necessity to innovate in the face of environmental destruction, and also literally, through guided tours through their workspaces.

The idea that insects are inedible by virtue of being disgusting, while common in the Netherlands where the researchers work, is not universal. Scientists in the edible insect lab commonly begin their public conversations by pointing out that people around the world find insects tasty. An opening refrain to their presentations is that "children love to eat insects" and they hope that children might be an entry point to adult markets. They explain with disappointment that cultural collisions have interfered with the tastiness of insects – that misguided Western influences teach children (and former colonial Others) that insects are gross, dirty, poisonous, and sickening.

Many of the scientists' appeals are directed toward a rational, deliberative consumer who will begin to eat insects because this is the responsible thing to do. Their workshops present insects as a humane protein source in two senses. First, their production is humane when considering the ecological health of the planet. The justifications here range from the phylogenetic distance between humans and insects (preventing disease transmission), to the increasing antibiotic resistance associated with current livestock production, to carbon footprint minimization as insect-protein is less energy-intensive than that of beef or pork (van Huis et al., 2013). Second, concerns for animal cruelty can be assuaged since the dark and crowded condition of industrial-scale production is their "natural" environment. In front of their audiences the scientists choose their words carefully: they speak of "growing" and "cultivating" instead of "raising" and refer to insect death as a harvesting rather than a culling or slaughter (see also Sharp, 2011). While they classify insects as *animalia* and not *plantae,* there is some thought that vegetarians may find these boundaries fuzzy enough to eat insects.

If many of their appeals to eating insects are made in the spirit of reason (the realm of universal facts), they also hold that when it comes to creating consumer demand for insects, reason does not work very well. Though reason and taste are often held apart in the Western sciences, for the scientists in this lab, concern for taste is necessary to bring about desired results. I have heard from various members of the research group that markets will only open if mouths will open. What they mean by this is that the shift of insects from an inedible to a food must begin with a "testing experience" (Stengers, 2005:188) of getting people to eat – ingest, chew, swallow – insects.

In their work, taste is not a fact to be uncovered but a quality to be achieved. While the mealworms, despite their slightly nutty flavor, may not be initially appetizing, with proper engineering and design the scientists believe they can make them so. To this end, the researchers enlist chefs who taste-test insect recipes and design cookbooks. So far, the chefs typically employ three strategies. One treats insects as a delicacy to be eaten whole, their bodies admired while consumed. Another grinds them into parts, incorporating them into meals in bits and pieces, for instance added to egg and flour to create a textured pasta dough or mixed with peanuts to make a crunchy sauce. In the third, they are rendered invisible, valued for their nutrients rather than their taste. One chef opines that if mealworms are ground together with hamburger at a ratio of 2/3rds beef to 1/3rd insect, no one will be the wiser. In this result, which they refer to as an "earth friendly bug burger," the insects can be eaten without ever needing to shift into a publicly accepted category of edibles.

A few of the researchers originally trained in chemical sciences have begun to study marketing techniques, hoping to generate ideas for how to distribute their products. They run taste experiments that aim to probe into "consumer response" (see also Solomon, 2013). In one experiment they served an array of insects prepared in different ways to a small sample of eaters. They added some insects to quintessentially "western" foods – mealworms into quiche, ground crickets as a topping to ice cream – while they prepared others in sauces or served them whole, replicating preparations from a Thai market. Following focus groups where the eaters could discuss their preferences.

While they will comfortably call these focus groups experiments they are also *experimental*, in the sense that they seek to generate ideas rather than to narrow down results or (re)solve, definitively, arguments about the best strategies to undertake. What they are learning is that sometimes it might be best to present insects as mundane, pointing out that they are regularly eaten in honey, shrimp, food dyes, and “allowable parts” deemed acceptable by food regulatory bodies. Other times eaters are inspired when insects are presented as exotic delicacies (think here of African clay pots boiling over with mopane worms, large plates of fried circadas served in Asian markets, or the sour appeal of worker ants when sprinkled over fish soup in place of lemon).

There are several sites of what might initially appear as controversy within the lab. Some of the scientists think that if people begin to eat insects in a way in which insect bodies are not initially obvious it might help to ease them into the category of an edible. Others are wary of sneaking insects into products, and instead want to openly demonstrate that insects – freeze dried crickets, for example – are delicious. Some think that coating insects in chocolate is a great strategy for getting people to become comfortable with insects’ tastes and textures. Others are skeptical of “trickle-down” production strategies, and do not find the creation of high-end products a worthwhile goal for research seeking to ease the ecological burden of eating livestock. While the researchers express uncertainty about how to resolve these disagreements, they also acknowledge that perhaps the certainty of resolution isn’t what they’re after. Perhaps this friction isn’t to be avoided, but helps to produce innovative ideas and novel methods.

In their work of developing appetites for insects, it is notable that the points of conflict that emerge pertain less to the realm of universal truth than to priority of design. They have found that cultivating appetites for insects does not depend upon the discovery of a fact, but the ceaseless production of work. The disagreements here are not over ontology, but over where to invest their resources and how to spend their own limited energies. They are learning to not seek to craft a single appetite but to be in a position to respond attentively to the appetites they both produce and encounter. Sometimes serving insect-pieces may make sense. Other times they might be eaten whole. Still at other times it might be best to hide them altogether. Rather than choose one strategy that will work the same everywhere, they can offer a range of options. The trick, they say, is to be able to adapt.

Results III: Making Global Markets

To attenuate global hunger and slow climate change, people must not simply eat insects in a single locale. To address the concerns of global food security that inspire their work, the products the scientists cultivate must circulate widely. Edible insects must travel the world. Because of this, the same scientists involved in laboratory experiments and consumer outreach also meet to discuss, examine, and evaluate possibilities for travel. Travel is part of their scientific endeavor.

One way to encourage mobility that they are exploring is by rearing, harvesting, and packaging insects in the Netherlands at an industrial scale (defined technically as more than one ton of fresh-weight insects produced at a single site per day) where they would then be shipped throughout the world. It is useful that most insects the researchers work with can be freeze-dried. Removing their fluids renders them light, more easily mobile, and eliminates the need for cold storage chains. Being ground into a powder further reduces bulk, aiding the efficiency of their circulation.

The researchers are finding, however, that too much focus on efficiency results in a product that people refuse to eat; counter-intuitively, the aim of efficiency undermines the product’s eventual efficacy. On a recent exploratory project to market their products in rural Kenya, researchers saw their ambitions for insect products deflated. When the idea of eating mealworms was presented to villagers who were accustomed to eating (delicious) termites or lake flies, many responded with disgust, seeing no natural connection between the creatures that the scientists had grouped together within the category of insect. Whereas taxonomic classification has gained power through its pretense of easily-mobile universality, in this case the organization of food through the taxonomic class *Insecta*, rather than through attention to taste or presentation was an impediment to mobility.

Responding to this, the scientists are searching for additional ways that their insects might travel. Another strategy they are testing is to transport them whole and live. In this regard, the box where they cultivate their insects is not just a site in which to conduct experiments but part of the broader research agenda: they have been studying the production and circulation of "boxed farming." This technique, which is being developed by a lab in the UK, consists of a flexible network of urban farms.[ii] Upending the image of open pasture and wooden barnyards, the farm here is a series of modular cabinets that might support upwards of 32,000 insects in a cascading set of drawers where, after six weeks of maturing, the insects within each metal box can be removed easily and then frozen or transferred "straight into the kitchen."

Locating the farm next to the kitchen has advantages of both taste ("freshness tastes better," one research tells me) and hygiene (less concern for spoiling). The short life cycle of insects also ensures that their production can be calibrated to carefully match demand. In contrast to animals with a long gestational cycle, problems of potential under or oversupply can be adjusted on a weekly basis. They also highlight the reduction of carbon emissions associated with food transport. "It can't get more local than this," one of the researchers tells me, pointing out that those concerned with the distance many traditional protein sources travel from "farm-to-fork" should love the design.

Yet though the image of replicability apparent in this self-contained box is seductive, the mobility of boxes does not simply proceed through the mechanics of multiplication. First, there is a problem of genetic diversity. Up until 2000, one Dutch company with whom the scientists worked focused exclusively on *Acheta domesticus,* producing more than 10,000 boxes of these crickets each week. Following a sudden and still-inexplicable population crash that could not be remedied by all of their efforts, the project ended. Today, the scientists are cautious that reliance on a single species of insect results in the dangerous vulnerability to disease and pest susceptibility seen in agricultural monocultures. The "scaling up" of boxes holding a single insect species risks jeopardizing the ecological security they seek to enhance. Because they hope to expand the genetic diversity of the species with which they work, they must have many kinds of boxes. In a further complication, most edible insects resist domestication and so, as the researchers branch out to incorporate more species, in many cases the "box" cannot ultimately be a box at all.

The boxes have also confronted the scientists with constraints to affordability. While they caution against potential hazards of scaling up a single species, they worry that they might become caught by the causality dilemma that few will eat insects if they do not increase production (thereby bringing down costs) but that they cannot bring down costs as long as few eat insects. It is a twist on a physiological notion of edibility, but they recognize that if the insects remain too expensive to produce or purchase, they will never move into a category of edibles. This is a large source of worry, but rather than respond by solving it directly, they are trying to address it by working around it. In places where insects have historically been eaten, "traditional methods" of cleaning and cooking have removed or neutralized poisons. Women, typically responsible for this, do it in the midst of other activities, organizing their methods of collection and poison extraction around both their daily lives and the insects' behavior. This would not work for mass-scale production in the Netherlands where labor time is focused and costly, but these methods may be effective in many of the regions where they want to promote the eating of insects, and they have begun to examine forms of non-intensive and non-industrial production as a means of reducing costs.

A third challenge to boxing lies in complicated traveling permits requirements. Several governing bodies do not want Dutch nutrient boxes entering their food markets. In many places where reported malnutrition rates are high and the scientists would like to make inroads, concern about the environmental consequences of introducing foreign species has led to prohibition of the importation of insects cultivated in the Netherlands. The scientists envision boxed farms as enclosed, self-contained systems, but not everyone is confident that there will not be leakages. In response, the scientists must incorporate diverse regulatory protocols into their designs for edibility, as well as attention to local preferences for tastes and textures.

The frictions around boxed-insect travel illuminate the practical difficulties that accompany attempts to replicate insects-as-food and to distribute this food into a (one) world market. As researchers try to scale-up insect production they are learning that there is not one, but many markets that must be engaged. As the objects they cultivate are multiple, so too are the markets for these objects (Callon et al., 2002). The ostensible *global* market comprises many different places where many different insects, including those not even taken to be insects, are bought and sold, refused and devoured.

Discussion: Contingent Edibility

A scientist and I have finished cutting carrots for the mealworms and are now sitting over cups of instant coffee in the lab's meeting room, where we are discussing the challenges of overcoming the taboo surrounding eating insects. He borrows my notebook to draw a picture of a model for transmission – Everett Rogers' classic "diffusion of innovations" model – that they have been using (1962). It is a model that is failing them, and they are wondering what other models for dissemination might more usefully guide their work. The illustration he draws is a standard bell curve, with time represented on its x-axis and adopters (people who will start to eat insects) as its y-axis. He explains that this vision of behavior transformation begins with a few key innovators. In time, if the trend is successful, it will spread out, bringing with it a wave of others. Soon many will be swept into the fold. At its peak the rate of transmission will slow. Finally, those laggards, who hold tightly onto their traditions, will be won over.

This vision of travel resonates with a pathogenic model of infection in which an entity spreads in such a way that it comes to dominate other entities through repetitive reproduction. This vision holds the allure of replication that accompanies perceived "immutable mobiles"— a term coined by Latour in reference to things that are made to travel unchanged (1987:227). In this model, behavior and object adopted remain constant—it is the quantity not quality of each that changes.

This allure of replicable immutability inspires both the powdered nutrients and the metal boxes. With the powders, replication is targeted through reduction: the bodies of insects, once distilled into a universal form of polyunsaturated fats and proteins, can travel without regard for the specificities of place. With the boxes, replication is targeted through multiplication: the single box, when added to other boxes, becomes a series that enacts scale in a literal sense.

Though each box holds its own microcosm, they are designed to be everywhere identical. This series of boxes, in which insects can be prodigiously and precisely harvested, purports to bypass the complications and uncertainties of variation by maintaining uniform internal continuity. While in the laboratory there is one box, and in the kitchen-side farm there may be one hundred, nothing has changed but the number.

Replication is an alluring model of travel and impact and one which has had a great deal of influence in the "expert field now self-identified as global public health" (Pigg, In Press). But it is notable that in the edible insect scientists' research this model for expansion is a broken model, the desired replication remaining out of reach. For edibility, like eating, does not happen through replication but through continual ex/change (see also Bertoni, 2013; Serres, 1982). It does not spread outward, from center to periphery, in a uniform, predictable pattern. It is not a single thing, unfolding in a singular world.

In the previous sections I have highlighted the diverse projects undertaken by insect scientists to underscore the continual, persistent contingency of edibility. They must navigate life stages, the temporality of digestibility, fluctuations in bioavailable nutrition, and complications in metabolic and trophic cycles. They must account for where insects are reared, what and when they have eaten, the quality of water they have consumed, and other matters that require engagement with the histories and topographies of place. The category of insects itself can be a problem: it often makes no local sense to lump delicious mopane caterpillars or termites with nuisance species of mosquitos, ticks, fleas and lice. Even species classifications do not hold, since they work not with species but with eggs, larvae, or pupae. They must also consider physiological, relational temporalities of insects and eaters, since it is through chewing, salivating, and swallowing that fats and proteins are absorbed or toxins are produced. They must then interact with regulatory bodies, permitting process, preservation techniques, and product affordability. These matters – as well as the values, tastes, and beliefs long associated with the establishment of the category of food (Douglas, 1972) – must enter into their research designs.

Attention to edibility challenges models for scientific impact based upon scalar expansion and replication. Edibility pushes away from the terrain of stable knowledge and determinate expansion, destabilizing centers and peripheries. Indeed, it is precisely when the researchers locate themselves as a center, crafting products that will travel outwards, that their work starts to fall apart. It is as a center that they find themselves with mealworms in places where people wanted lake flies, rejected permits, displeasing tastes, and feed too toxic to safely grow food.

The contingency of edibility is not always apparent when listening to the researchers. There are times that they treat edibility as an inherent property of the insects with which they work. The researchers are sometimes seduced by the simplicity of the OWOH model of security in which health – and the world itself – can be tackled through singular, uniform, and shared approaches. But if the researchers at times speak of creating a singular product or a singular market for insects, in practice they are assembling many products and many markets. If they talk about their insects and boxes traveling into the world, in practice they have found themselves engaging with many different worlds. Just as they treat edibility as locally and temporally contingent within their laboratories, so are they recognizing that the spread of edibility must also be done through small, specific engagements. There is no conduit of a network along which their product will travel. In the lab and beyond, edibility "is always a practical problem, never a universal problem, mattering for everyone" (Stengers, 2005:193). Rather than aim to take a small box and magnify it outwards, cultivating edibility requires the endless, difficult work – perhaps, given their concerns, this is better called "care" – of learning from environments unlike their own.

It is telling that the team has started to send their researchers to other countries to live and work with farmers and scientists there for a few years at a time. Some of the scientists in the group are also working with the FAO to build research stations in places where insect eating is common, hoping to learn how, when, and what people eat. They are spending time in maggot factories in China and termite farms in Mexico. They have recruited brilliant scholars from beyond their own national border to work in their lab—to teach them more about what they do not know. They are researching who will welcome a porridge made from ground nutrients added to warm water and who will not. They are studying how insects grown in uniform boxes might be prepared, diversely, according to an array of preferences and tastes, and they are looking into community-based approaches to cleaning and preparation. The contingency of edibility is not, for them, a hopeless conclusion, but indicative of the importance of situated experimentation, creative innovation, and openness to the unknown.

Conclusion: Situated Travel

There is an important lesson in the scientists' work on edibility for the OWOH agenda. There is real, material suffering underlying many concerns for food security; it is obvious that impacts are needed and there is much work to be done. But the scientists in the edible insect lab are finding that this work cannot be done effectively when tackling a generalized world. Instead they must accord to the tastes, policies, and markets of particular places. Travel that works, when it works, does not proceed through distant networks, but involves interaction that is immediate, and never complete (see also Beisel & Schneider, 2012; Morita, 2013). Even travel is situated.

Security – those infrastructures through which this travel is orchestrated – might in turn be improved by incorporating more contingency into ambition for intervention and impact. To date, much of the focus of biosecurity – a field rife with analogies to military defense (Clark, 2013; Lakoff & Collier, 2008; Martin, 1994) – focuses on calculating risks and then mitigating change. The will to *secure* is taken as an imperative to shore up a border against a shared enemy; debate and difference become cast as problems to be reconciled into the consensus of a common vision. Meanwhile in the insect lab, difference and debate are not (only) to be feared; they are also generative sources of data and inspiration.

There are no doubt risks in the edible insect experiments. Altering trophic relations through insect cultivation inevitably produces unknowns in which guaranteed security is simply not possible. When I ask the scientists about this, they quickly acknowledge: "more research is needed." Yet, they do not want to devote all their energy to lessoning uncertainty; since predation is a precondition of eating, there is simply no possibility of life without risk. Especially given the known rise of zoonotic infection in conventional livestock addressed by other authors of this special issue, they suggest we (eaters) may have much more to fear from what is familiar than what is not.

Besides, when it comes to the innovation of goods to eat, that which is not yet imaginable – the indeterminate travel of the wings of the butterfly – might become quite useful. Sometimes impact might be achieved from making a sweet, warm broth to be drunk in the chilly evening at the end of a long day; at other times from the crunchy pleasure a delicious meal when there is not much food to go around; and at other times still, from attending closely to the feed of what we feed on or the water in which this feed is grown. These strategies cannot be scaled up, taken from one site and replicated elsewhere. Instead, difference in tastes, appetites, and politics must be attended to—gathered together, but not assimilated (Hinchliffe, 2008:95). As the scientists' research shows, collaboration is not always enhanced by sharing a common vision. Instead, to impact the food supply of "the world," it might be necessary to allow for many different worlds.

Still need to standardize references in upper and lower case—will do this last.

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[i] http://www.onehealthinitiative.com/, last accessed October 1, 2013.

[ii] For more see: http://www.core77.com/blog/case_study/case_study_ento_the_art_of_eating_insects_21841.asp, last accessed Oct 1, 2013