Can there be a common, risk-based framework for decisions around live insect trade?

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Summary

A network of scientists involved in shipment of live insects has met and generated a series of articles on issues related to live insect transport. The network is diverse, covering large-scale commercial interests, government operated area-wide control programmes, biomedical research and many smaller applications, in research, education and private uses. Many insect species have a record of safe transport, pose minimal risks and are shipped frequently between countries. The routine shipments of the most frequently used insect model organism for biomedical research, *Drosophila melanogaster*, is an example. Successful largescale shipments from commercial biocontrol and pollinator suppliers also demonstrate precedents for low-risk shipment categories, delivered in large volumes to high quality standards. Decision makers need access to more information (publications or official papers) which details actual risks from the insects themselves or their possible contaminants, and should propose proportionate levels of management. There may be harm to source environments when insects are collected directly from the wild, and there may be harm to receiving environments. Several risk frameworks include insects and various international coordinating bodies, with experience of guidance on relevant risks, exist. All stakeholders would benefit from an integrated overview of guidance for insect shipping, with reference to types of risk and categories of magnitude, without trying for a single approach requiring universal agreement. Proposals for managing uncertainty and lack of data for smaller or infrequent shipments, for example, must not disrupt trade in large volumes of live insects, which are already supporting strategic objectives in several sectors.

Keywords

Insect – Trade – Risk analysis – Intergovernmental treaties and organisations – Courier services

Introduction

This thematic issue of the World Organisation for Animal Health (OIE) *Scientific and Technical Review*, and earlier discussions reported by Imperial College London (1), identified a series of potential risks arising from live insect trade. This article considers those risks related to the nature of the living and time-sensitive cargo, while recognising

that negative outcomes can occur if the motivation and intended use for trade and effectiveness of regulation are not taken into account along with biological factors (2).

Risks *to* the trade not addressed here relate to market factors (e.g., cost of production; supply competition), or disruption of routine air traffic due to natural disasters (e.g., 3) or the impact of uncertainties in travel policies such as those related to the Covid-19 pandemic (4), all of which may affect the safety, efficiency and quality of insect transport. Perceptions around potential threats, such as terrorist attacks, have also resulted in additional security requirements, which hinder live insect trade, without a direct causal link to the perceived harm (5). Such risks will continue to challenge global trade but are not unique to live insect trade.

During the course of the past year, several of the authors from this network discussed their experiences with the aim of deriving improved conditions for international live insect trade. The aim of the discussions was not to reach a final conclusion by the time of publication, but rather to clarify issues and propose solutions. As laid out by the OIE Director General Éloit (Preface (6), this issue), the aim of the thematic edition is to open this important discussion to a range of stakeholders with the varied perceptions.

Oliva *et al.* (7, this issue) document what is already recognised in the sector: that complexity in regulation leads to undeclared trade. Parallel trade that eludes management increases the very risks all parties seek to avoid. For this reason, and to improve efficiency for those already shipping insects, the question arose whether a common framework could be developed to manage risks from live insect trade more proportionally and rationally than is the current practice. Such a framework, using vocabulary and language understandable to all stakeholders, should include aspects of evaluation, classification and management of the risks identified. This framework should direct the user to options that are feasible in the likely settings and that are in proportion to the likelihood and potential impacts.

Risk-based decision making is a key principle for international treaties addressing management of threats to biodiversity and plant health, and animal and human health. Harmonisation, however, is the other option that avoids each country conducting risk analysis, on a case-by-case basis. For matters relating to Sanitary and Phytosanitary Measures (SPS), harmonisation is the application of science-based standards or norms that are jointly adopted by the member countries. Harmonisation saves resources by providing transparency, consistency, and a clear reference point for precedence from existing trade to all stakeholders in the process. It is most suitable for situations in which the threat or hazard can be classified, the probability of its occurrence estimated, and broadly accepted measures and means for managing that risk are agreed. The parties involved still may seek harmonisation of principles, criteria, indicators, and so forth while not reaching specific harmonised guidance when there is too much variation in conditions, or substantial uncertainty or disagreement around the risk or the efficacy of the risk mitigation to have a detailed standard, or where solutions are not feasible for some locations or scenarios. General harmonised guidance is useful but not as resource-saving as detailed and specific guidance, which can replace the case-by-case risk analysis.

Factors affecting risk from shipping live insects

Mumford & Quinlan (8, this issue) summarise the nature of the risks identified throughout this thematic issue. Three of these risk groups are primarily logistical, procedural and policy challenges: delays and loss of quality; refusal of carriage; and high and variable costs. The other group of issues relates to biologically-based risks to the environment and health, which is the focus of this section.

The risks identified from live insect trade are highly dependent upon a number of factors:

a) the species (or biotype if expressing particular traits);

b) their intended use;

c) life stage(s) in the shipment (egg, larva, pupa, or adult);

d) hardiness or ability to survive and spread under prevailing conditions (or at all, if somehow modified);

e) capacity to transfer or vector disease; or to become a pest itself.

Many insects pose minimal risks and are shipped frequently between countries. The routine nature of such shipments presents the opportunity for evaluating risk based on volume without incident, which should lead to expedited review and processing. The insect used most frequently as a model organism for biomedical research, *Drosophila melanogaster*, falls into this category (9).

When transport data is lacking, or some risk is identified, existing frameworks such as the current OIE process for import risk assessment could be annotated for this purpose (10).

The authors agree that the production and packaging phases for large volumes of insects should be reviewed or audited rather than attempting to certify the output, insect by insect. This contrasts with the approach of certifying individual animals, which is more appropriate for livestock, for example.

Further work is needed to identify the best party or parties to carry out such review, audit or certification, when necessary, but it would require additional training for any existing national inspectorate. Some researchers have highlighted the need for third party certification of insectaries (2, 11).

In addition to describing the range of risk profiles around each factor of the trade or shipment, a common framework could support agreement on assigning responsibility, in order of the phase when it is most likely to occur:

To be managed at the source

- Loss of biodiversity due to over-harvesting or damage from harvesting from a wild population;
- Introduction of contaminants to the insects destined for transport (parasitoids, parasites, symbionts, pathogens, or

otherwise associated living organisms) that could affect the health of valued insects themselves in the receiving country, facility or colony, particularly those under research and in managed production or those with protected status;

- Introduction of zoonotic or animal diseases, or plant diseases, through unintended infection of insect vectors being shipped for research or control programmes (those intentionally infected for research purposes would be destined for biosecure or quarantine facilities and handled with greater restrictions and precautions);
- Worker health issues relating to allergic response from contact with insects or other arthropods (more likely under high production scenarios).

To be addressed primarily during transport

- Lost opportunities due to high cost of transport and handling or uncertainty around acceptance of a shipment;
- Lost opportunities due to limited transport options (generally air carriers) for routes of interest, e.g., because of limited ports of entry for the shipment, or refusal by carrier to accept live insect trade;
- Damage to quality or loss of insects due to
    - Refusal of shipment by courier, at beginning of transport or during transit;
    - Transport delays, re-routing, or lost packages;
    - Failure to maintain required handling or environmental conditions;
    - Refusal or delay by transit or border control authorities, due to incorrect documentation, unclear requirements, or other miscommunications;
    - Refusal or delay by transit or border control authorities due to lack of available staff qualified to review the shipment or documentation;
- Interruptions in research or field control programmes due to delays or reduced quality of shipped insects, which could lead to other serious impacts such as outbreaks of pests, increase in vector species, loss of biodiversity, etc.

- Escape of insects due to breach in packaging (that are able to survive in conditions encountered at the time of breach); emergence of insects (to adult stage, for example) due to serious delays in transport.

To be managed primarily by the end users

- Accidental introduction of invasive insects detrimental to health, food production or protection of biodiversity;
- Accidental introduction of nuisance species;
- Accidental or intentional introduction of agricultural, forestry, or zoonotic pests already present in the receiving area, but that have variations making the population harder to control, for example insecticide resistance;
- Introduction of non-native insect populations that overwhelm local population genetics, with adverse consequences to biodiversity;

As noted above, the risks associated with the transport phase are generally related more to policies and logistics than to inherent biological features. Clarifying responsibility for each of these issues, or their lack of relevance for some types of trade, will itself improve efficiency in trade.

Roles and Responsibilities

There are existing guidelines, standards, and in some cases regulations that have long supported successful trade in live insects (Quinlan *et al.* (12), this issue). Several outstanding challenges could be resolved with greater awareness and coordination among the parties involved in this special trade. Table I suggests where responsibility naturally would lie in terms of ensuring safe trade and supporting effective and timely delivery.

INSERT TABLE I

In contrast, courier services are generally private companies with concerns of their own: will my workers be safe? will there be delays or confusion around documentation? will we face some liability when we

cannot control the delay? It seems important to start with support to these companies by providing clear, timely information through some central, easily accessible hub or clearing house that will guarantee the most up-to-date material and the ability to explain nuances in guidance for various situations. This presents an additional role for the sectors using live insects: to encourage courier companies to participate in supporting insect uses that are aiming at more environmentally responsible behaviours and contributions to the Sustainable Development Goals.

More recent concerns presented by stakeholders, such as animal welfare for insects, may also be addressed with greater transparency within integrated guidance. Again, educational material may prove more valuable than further guidance or standards.

One immediate step, as alluded to in Mumford & Quinlan (8) is to hold meetings and form a network of interested people and invite the courier sector to work together to express concerns and potential solutions to the issues affecting international live insect trade. Such a discussion would provide a useful opportunity and platform for both the insect industry and those transporting insects to mutually understand:

- What are their experiences shipping live insects?
- What difficulties do they face?
- What would make their task easier?
- How easily are existing procedures being followed?
- How could other useful stakeholders be brought into the process by the transport sector?
- Who couriers can rely on for accurate and up-to-date information?

While those working with large scale, regular shipments of insects generally have negotiated a workable process for shipping, those handling less frequent and smaller volume shipments encounter more uncertainty.

Experience shows that carrying many types of appropriately packaged insects on passenger flights could be a safe and efficient way to

transport small quantities of valuable insects for specific purposes, such as research. To ensure safe and efficient transport via this option, there should be appropriate guidance and streamlined procedures agreed with carriers and biosecurity authorities. The option may require some change in the guidance from the International Air Transport Association (IATA) Live Animal Regulations (LAR) (14) to include animals other than companion pets on board. Specific documentation should be required, along with notification to the carrier and subject to approval of the carrier. Not all insect species, uses, sources, or destinations are suitable for hand carriage.

The International Standard on Phytosanitary Measures relating to intentional transport of beneficial organisms, ISPM 3 (15), has been praised particularly for its description of roles and responsibilities of the relevant authorities, in this case the importing and exporting country National Plant Protection Organizations (16). Lack of clarity on which entity is responsible for each aspect of the trade has led to higher risk behaviour, such as undeclared or mislabelled transport of live insects, and risk avoidance, such as refusal of carriage (7).

Table II defines some areas where greater coordination and recognition could make the relationship among the various treaties and guidelines clearer for those implementing them in the live insect trade sector. A joint statement from the international bodies providing global guidance on best practice would further support clarity although the most appropriate lead for some topics remains undefined.

Those international bodies and associations representing various components from source to use in the live insect trade will be central to mapping out a path to more consistent guidance. Clarifying the role of the existing authorities will be a first step. For example, the International Plant Protection Convention (IPPC) community can define how far ISPM 3 should be stretched beyond the mandate of that treaty, and whether it is appropriate to reference or even annex it to other guidance (e.g., 14). The OIE can reach an internal conclusion about the appropriate role of official Veterinary Services in certifying health of insects for shipment.

INSERT TABLE II

Conclusions

While risks exist, most unintended insect introductions occur through trade in agricultural commodities, ornamental plants, associated packaging, and movement of people (17), rather than via intentional insect importation. E-commerce, of ornamental plants or other pathways for insect movement, has added to this risk. Many cases of largescale insect trade have longstanding records of safe and successful shipment.

Experience shows successful trade, often at very large scales, is achieved between government programmes, for example, trade in sterile insects, and by the well-established companies for invertebrate biocontrol agent production and distribution. New parties to insect trade, those working with research, innovations and pet sectors, are not always so successful. If live insects are packaged and handled properly, little external risk exists during transport: damage to the insects themselves is the greatest worry. Despite low risks, getting approval to ship the insects in the first place is often a substantial hurdle to trade.

Defining the problem is an important first step to formulating a solution. Drawing up a single set of guidelines that would cover every insect species on all potential routes and for all normal purposes is not feasible, but harmonising concepts and principles should be. Stakeholders would benefit from informal guidance, integrated guidance from different sources, or joint statements from international authorities that align with the existing, related frameworks. Furthermore, we cannot rely on assumptions regarding transport methods: while informal and undeclared transport of live insects is against everyone's interest, hand-carried insects moved in small numbers with appropriate documentation and packaging by responsible parties could resolve a number of the current hurdles if proper procedures and permits are obtained.

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Table I

Roles and responsibilities during transport of live insects

Use at destination	Shipper	Carrier / Freight Forwarder	Receiver	End User
Non-confined research/ education	• Assure the integrity of the consignment • Ensure the correct documentation is provided to carrier* • Advance discussion with End User whether additional documentation (e.g., material transfer agreement or MTA) or conditions are required for their institution/use • Possible efforts to obtain "safe-use" status recognised	• Routing: ensure appropriate routing (shortest or most secure route) • Transhipment: when transfers are necessary, precautions must be taken to assure special care, expeditious handling in transit • Verify that the shipment complies with marking and labelling requirements, and documentation requirements • Track the shipment; send prior notice documentation for inspection, clearance • Ensure delivery respects the shipper requirements	• Ensure the Nagoya Protocol* requirements are met • Obtain the necessary authorisation(s) from national authorities for the importation • Provides the sender with the required documentation • Possible bulk delivery and redistribution for small batches of unusual and varied specimens	• Responsible use • Measures to prevent release into the environment
Confined research				
Pets/ Recreational/ Zoos				
Confined rearing (colony starters)	• Certificate of analysis or other documentation of taxonomic identity (including strains) • Certify health status /Non contamination by parasites or pathogens		• Obtain the necessary authorisation(s) from national authorities for the importation • Provides the sender with the required documentation	• No release in the environment

Greenhouse commercial release	• Warranty that the product respects the purpose intended (e.g. sterilized, marked) • Biosecurity protocols and tracking systems • Assure the integrity of the consignments • Batch or process health certification • Ensure correct documentation			• Respects conditions of use authorisation: no release in the environment
Field releases (commercial/ conservation)				• Ensure releases are free of contaminants
* Nagoya Protocol (11)				

Table II

Topics for authorities relating to live insect trade to clarify before proceeding to coordination and additional guidance

Viable insects (which will remain in confined conditions, e.g. for research in a lab)	
Insects to start research colonies	What are the responsibilities of those sending seed populations for research settings? Are MTAs sufficient for control over conditions of use by receiving entities? Are the 'self-regulation' initiatives such as under associations sufficient guidance or are legally-binding approaches required? Can this area be covered by an international agreement or standard, such as ISPM 3 to avoid inconsistencies and save resources?
Insects for use in research	Should model organisms for biomedical research (especially *Drosophila melanogaster*) receive special treatment to expedite delivery based on low risk and the large number of shipments? If a special category is allowed for transport of live insects designated to remain in a research setting, what national entity would be appropriate to ensure these conditions are met? Review how the successful precedent for *Drosophila* shipments as 'beneficial' and 'low risk' could be extended to other common research applications, based on risk profile and the large number of shipments
Viable insects (which must be released in order to serve their function)	

Biocontrol, pollinators, and other beneficial insects	Review the current successful shipping processes in this sector as a basis for wider guidance Extend examples of pre-designated 'Beneficial insects' that are recognised for transport IPPC – clarify appropriate use of ISPM 3 and Phytosanitary Certificates for live insect trade? What is the scope of use and limitations? An official statement would be far reaching in terms of consistency in requests for this documentation. OIE – clarify appropriate use of Sanitary Certificates in terms of health of insects other than *Apis* and *Bombus* spp. OIE, IPPC, Convention on Biological Diversity (CBD) – is there a way to coordinate shipment of insect pollinators that combines the very few notifiable diseases relevant to insects that are monitored by OIE with other requirements to maintain global pollinator health and biodiversity? Could an international label address all issues in one place (e.g., status with the Convention on International Trade in Endangered Species of Wild Fauna and Flora, CITES)?
Sterile or modified insects for areawide control programmes	The Food and Agriculture Organization (FAO) and the International Atomic Energy Agency (IAEA) have overseen much of this research, transport, and trade over many decades. Can their role be augmented to cover area-wide control programmes outside the intergovernmental agreements? Needs to include those not treated with irradiation, as well as existing oversight for radiation-induced sterility. What would need to change in the terms of authority to facilitate this, and would there be any other entities better suited?
Pet and educational use	How to organise coordination to ensure rare species and marginal habitats are not over-exploited? While these may not be intentionally released, what can be put into place to reduce the probability of escape or release into the environment? What authorities should oversee this trade?

Viable insects (surviving for at least the first generation at the receiving site)	
Modified populations of live insects	CBD, OIE, IPPC – will modifications be evaluated based on the change in risk of the insects produced for trade (e.g., sterility; limited persistence; gene drive components)? Or is a parallel process needed for each type of modification? (Modification via chemical treatment or irradiation; insertion of symbionts; paratransgenesis; insects used for delivery systems (entomovectoring); genetic modification of the insect; etc.)
Medical or industrial use	What authorities should oversee insects or other organisms transported for these purposes? Is there a role for the World Health Organization (WHO) to provide guidance, or is it only a matter to overseeing the transport phase?
Non-viable insects or other arthropods	
Insect-based products	Codex Alimentarius – will this body take the lead in preparing standards when insects are an intentional component or sole ingredient of human food or animal feed (rather than an unwanted contaminant)? OIE – is additional guidance needed to ensure insect-based animal feed is safe for consumption?
Dead insect samples or collectables	OIE – is there any animal disease that could be spread mechanically which remains viable after the insect is no longer viable? What actions would be possible to manage that (very limited list)? Should the safety of non-viable samples for reference collections, hobby collectors, etc be overseen by a different type of organization?