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

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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 large-scale 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) that 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

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

Introduction

Over the past year, the authors of this article participated in an informal network of scientists from research, regulatory and industry sectors who discussed their experiences in international trade of live insects. Their aim was to promote improved conditions for this trade. They did not plan to reach a conclusion by the time of the publication of this issue, but rather to clarify problems and propose solutions. As laid out by the Director General of the World Organisation for Animal Health (WOAH, founded as OIE), Monique Éloit, in the preface [1] of this issue of the *Scientific and Technical Review*, the aim of this thematic edition is to open this important discussion to a range of stakeholders from varied perspectives.

Throughout this issue and in earlier discussions reported by Imperial College London [2], experts have identified a series of risks arising from live insect trade. This process has confirmed conclusions from other researchers – that evaluating biological risk factors and considering a shipment's intended use are both essential for creating effective guidance or regulation [3].

Oliva *et al.* [4] document what is already recognised in the sector: uncertainty or complexity in regulation leads to undeclared trade. Parallel trade, which eludes management, increases the very risks all parties seek to avoid. To decrease parallel trade and to improve efficiency for those already shipping insects within regulations, the informal network considered whether a common framework can be developed to manage risks more proportionally and rationally than is the current practice. Such a framework, using language understandable to all stakeholders, should evaluate, classify and manage identified risks arising from a range of pathways presented by live insect trade. The framework should direct users to take actions that are feasible in likely scenarios and proportional to the likelihood of potential impacts.

Risk-based decision making is a key principle for the international treaties that manage threats to biodiversity and plant, animal and human health. Harmonisation through prescriptive standards is the other key principle, as it avoids each country conducting risk analysis on a case-by-case basis. In this context, harmonisation is the application of science-based standards or norms that are jointly adopted by the member countries. It saves resources by providing transparency, consistency and a clear reference point for precedence from existing trade to all stakeholders in the process. Harmonisation is most suitable for situations in which the threat or hazard can be classified, the probability of its occurrence can be estimated and broadly accepted management measures are available. When there is too much variation in conditions, or there is substantial uncertainty or disagreement around the risk or the efficacy of mitigation measures, or solutions are not feasible for some locations or scenarios, parties may still seek to harmonise their principles, criteria, indicators and so forth, but may not reach specific harmonised guidance. General harmonised guidance is useful, but it is not as resource-saving as guidance that is detailed and specific, which can replace case-by-case risk analysis. If harmonisation is possible for the range of insects traded internationally and their variety of uses, then a common framework could be developed.

This article recommends which parties could take responsibility for each risk in the trade of live insects. It provides international treaty organisations a list of issues to resolve. It also identifies areas for further cooperation between responsible parties, to be discussed as a harmonised framework is created.

Risks to the trade not addressed in this article relate to market factors (e.g. cost of production and supply competition), disruption of routine air traffic due to natural disasters (e.g. [5]) and the impact of uncertainties in travel policies such as those related to the COVID-19 pandemic [6]. All of these 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 that hinder live insect trade, without a direct causal link to the perceived harm [7]. Such risks will continue to challenge global transport but are not unique to live insect trade.

Factors affecting risk from shipping live insects

Mumford and Quinlan [8] summarise the types of risks identified throughout this thematic issue. Some of these risks relate to logistics, procedures and policy: for example, delays and loss of quality, refusal of carriage and high and variable

costs. Other risks are biological risks to the environment and health. These risks occur primarily during production and use. If live insects are packaged and handled properly, little biological risk exists during transport: damage to the insects themselves is the greatest worry.

When evaluating biological risks posed by live insects from production through use, the level of risk depends upon a number of factors:

- the species (or biotype, if expressing particular traits);
- the life stage(s) in the shipment (egg, larva, pupa or adult);
- the insects' reproduction capacity, hardiness and ability to survive and spread under prevailing conditions (or at all, if modified);
- their intended use and the prevailing conditions in the receiving environment;
- their capacity to transmit or vector disease or to become pests themselves.

While each of these factors warrants review, many insects pose minimal risks and are shipped frequently between countries. The routine nature of such shipments presents the opportunity for collecting data and evaluating risk based on volume. Those shipped without incident create a precedent that should lead to expedited review and processing in the future. 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 residual risk is identified, existing frameworks, such as the current WOAH process for import risk assessment [10], could be annotated accordingly.

Finally, national authorities should be aware that unintended insect introductions are more likely to occur through trade in agricultural commodities and ornamental plants, associated packaging and movement of people [11] than via intentional insect importation. E-commerce, of both ornamental plants and insects, has added to the risk of unintended introductions, in part because it is easier to regulate a large production facility with limited species of insects than to regulate individual hobbyists who trade online in companion insects [3].

Assigning responsibility for each risk

A common framework should specify which entities are responsible to evaluate and manage each risk. Responsibility would be assigned according to the phase when the risk is most likely to occur:

To be managed at the source

- Loss of biodiversity due to over-harvesting or harvesting from a wild population;
- Introduction of contaminants to the insects destined for transport (parasitoids, parasites, symbionts, pathogens or other associated living organisms) that could affect the health of insects in the receiving country, facility or colony, particularly those under research and in managed production or those with protected status;
- Introduction of zoonotic, animal or plant diseases through unintended infection of shipped insects (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 (this case is most likely under high-production scenarios);
- Inadequate packaging or methods for maintaining required environment for insects during shipment.

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 for routes of interest, e.g. because of limited ports of entry or a carrier's refusal to accept live insect trade;
- Damage to or loss of insects due to:
  - refusal of shipment by courier at the beginning of or during transit;
  - transport delays, rerouting 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;
- Escape of insects due to extraordinary breach in packaging, when insects are able to survive in conditions encountered at the time of breach – this assumes correct packaging at the start;
- Emergence of insects to adult stage, for example, due to delays in transport and lack of instructions for destruction and disposal;
- 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, increases in vector species and loss of biodiversity.

To be managed primarily by the end users

- Accidental introduction of invasive insects detrimental to health, food production or biodiversity;

- Accidental introduction of nuisance species;
- Introduction of agricultural, forestry or zoonotic pests already present in the receiving area, but that have variations making the population harder to control, such as insecticide resistance;
- Introduction of non-native insect populations that overwhelm local population genetics, with adverse consequences to biodiversity.

The risks associated with the transport phase generally relate more to policies and logistics than to inherent biological features. Clarifying who has responsibility for each of these issues, and which issues are irrelevant for some types of trade, will itself improve efficiency in trade. Table I suggests where responsibility naturally would lie in terms of ensuring safe trade and supporting effective and timely delivery.

Lack of clarity about which entity is responsible for each aspect of the trade has led to high-risk behaviour, such as undeclared or mislabelled transport of live insects, and risk avoidance, such as refusal of carriage [4].

Cooperation with couriers

Courier services are generally private companies with concerns for their own interests. These concerns include whether their workers will be safe, whether there will be delays or confusion around documentation and whether they will face liability if the content arrives dead or in a deteriorated state. A central, easily accessible hub or clearing house providing straightforward, reliable information would support these companies' decision-making in regard to consignments of live insects. This entity would need to guarantee the most up-to-date material and explain nuances in guidance for various situations. It may also encourage courier companies to support insect uses that contribute to environmentally responsible behaviours and the United Nations Sustainable Development Goals.

One immediate step, as alluded to in Mumford and Quinlan ([8], this issue), is to form a more formal network that will meet with representatives from the courier sector and identify concerns and potential solutions to the issues affecting international live insect trade. Both the insect industry and

Table I

Roles and responsibilities during transport of live insects

Use at destination	Shipper	Carrier/freight forwarder	Receiver	End user
Non-confined research/education Confined research Companion insects/ recreation/zoos	– Assure the integrity of the consignment – Provide the correct documentation to carrier – Discuss with end user whether additional documentation (e.g. material transfer agreement) or conditions are required for their institution and the intended use of the shipment – When possible, select from a 'green list' of species or strains that are recognised as safe for the purpose	– Ensure appropriate routing along the shortest or most secure route – Assure special care and expeditious handing during transit transfers – Verify that the shipment complies with marking, labelling and documentation requirements – Track the shipment; send prior notice documentation for inspection and clearance – Ensure that the delivery respects the shipper's requirements	– Ensure that the Nagoya Protocol* requirements are met – Obtain necessary authorisation(s) from national authorities for the importation – Provide the sender with required documentation – Offer possible bulk delivery and redistribution for small batches of unusual and varied specimens	– Use the shipment responsibly – Take measures to prevent release into the environment in the case of confined uses
Confined rearing (colony starters)	– Provide certificate of analysis or other documentation of taxonomic identity, including strain or biotype – Certify health and non-contamination by parasites or pathogens – Implement biosecurity protocols and tracking systems – Assure the integrity of the consignment – Provide certification of batch or process health, compliance with treatment (e.g. sterilisation) or marking or other contractual requirements – Ensure correct documentation for authorities		– Obtain necessary authorisation(s) from national authorities for the importation – Provide the sender with required documentation	– Do not release into the environment
Greenhouse commercial release				– Respect conditions of use
Field releases (commercial/conservation)				– Ensure that releases are free of contaminants

*Nagoya Protocol [12]

those transporting insects could better understand the other's experiences through such discussions. Questions to be dealt with include the following:

- 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?
- Could other useful stakeholders be brought into the process?
- On whom can couriers rely for accurate and up-to-date information?

Solutions for small and large shipments

In general, those working with large-scale, regular shipments of insects have generally negotiated a workable process for shipping, but those handling less frequent and smaller shipments encounter more uncertainty. Experience shows that a safe and efficient way to transport small quantities of insects for specific purposes, such as research, is hand carriage in appropriate packaging on passenger flights. To guide this type of transport, carriers and biosecurity authorities must agree upon streamlined procedures. These may require changes to the International Air Transport Association Live Animals Regulations [13] to allow specified animals other than companion animals on-board. The shipper would need to notify the carrier, supply required documentation and receive the carrier's approval to take advantage of this option. Not all insect species, uses, sources or destinations are suitable for hand carriage.

When validating health for a large shipment of insects, an approach more consistent than the current ones, which range from having little oversight to requiring a sanitary certificate for each consignment, would entail a scheduled review or audit of the production and packaging. A production audit and check of packaging are more appropriate to insect trade than a review of the health of individual animals, as is done for livestock. Further work is needed to identify the best party, or parties, to carry out such review, audit or certification. For any existing national inspectorate, it would require additional training. Other researchers have also highlighted the need for third-party groups to certify insectaries for small- or medium-scale production [3, 14].

Coordination on unresolved issues

Several other outstanding challenges in the trade of live insects could be resolved with greater coordination among the parties involved. Table II defines some areas where coordination could clarify the relationship among the various treaties and guidelines for those implementing them. A joint statement from the international bodies, providing global guidance on best practices, would further support clarity, even if the most appropriate lead for some topics remains pending.

Those international bodies involved in the various aspects of live insect trade, from source to use, will be central to mapping out more consistent guidance. Clarifying the role of the existing authorities will be a first step. For example, the International Standard for Phytosanitary Measures (ISPM) No. 3 [15] has been praised for its descriptions of the roles and responsibilities of the relevant authorities in intentional transport of beneficial organisms. The International Plant Protection Convention (IPPC) community can define how far ISPM No. 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. [13]). The World Organisation for Animal Health can reach an internal conclusion about the appropriate role of official Veterinary Services in certifying health of insects for shipment. International advisory and industry bodies that have prepared best-practice guidance on particular species and uses could more effectively engage the parties that set standards if funding were available for this type of cooperation.

Conclusions

Successful trade of live insects is achieved, often at very large scales, by well-established companies dealing in invertebrate biocontrol agents and by global distribution networks for *Drosophila* for research and educational purposes. Large numbers of sterile insects are traded safely and effectively between government programmes and some private associations. But for parties new to insect trade and those working with research and innovations, getting approval to ship the insects in the first place is often a substantial hurdle, and those trading informally, such as the companion animal sector, may avoid oversight entirely. Informal and undeclared transport of live insects is against everyone's interest, yet unclear and inconsistent regulation and guidelines hamper compliance.

Stakeholders would benefit from an integrated summary of the guidance from different sources, as well as from joint statements from international authorities regarding the scope of existing frameworks, including issues raised in Table II. The various parties should not have to rely on merely their own assumptions and interpretations regarding policies and protocols. Risks identified from the harvest, production and use phases should be better described and managed based on established risk-based approaches.

Drawing up a single set of guidelines to cover every species, or modification, on all potential routes and for all likely uses is not feasible, but harmonising concepts and principles should be. While development of a universally accepted framework is some ways off, creation of a central hub for disseminating timely, reliable information would support decision-making in the meantime.

Table II

Topics for international authorities to clarify before coordinating additional guidance in live insect trade

Viable insects that will remain in confined conditions, such as a lab	
Insects to start research colonies	What are the responsibilities of those sending seed populations for research settings? Are material transfer agreements sufficient for control over conditions of use by receiving entities? Are 'self-regulation' initiatives sufficient, or are legally binding approaches required? Can this area be covered by an international agreement or standard, such as International Standard for Phytosanitary Measures (ISPM) No. 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 their history of low risk over many shipments? If a special category is allowed for transport of live insects designated to remain in a research setting, what national entity would ensure these conditions are met? How can the successful precedent for *Drosophila* shipments as beneficial and low risk be extended to other common research applications, based on risk profile and the large number of shipments?
Viable insects that must be released to serve their function	
Biocontrol, pollinators and other beneficial insects	How might the current successful shipping processes in this sector serve as a basis for wider guidance? What other insects might be pre-designated as 'beneficial insects' that are recognised for transport? International Plant Protection Convention (IPPC) – What is an appropriate use of ISPM No. 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. World Organisation for Animal Health (WOAH) – What is an appropriate use of sanitary certificates for the health of insects other than *Apis* and *Bombus* spp.? WOAH, IPPC, Convention on Biological Diversity (CBD) – Can insect pollinators be shipped in a way that coordinates the few notifiable diseases relevant to insects monitored by WOAH with other requirements to maintain global pollinator health and biodiversity? Could an international label provide one place to address all pertinent issues (e.g. status with the Convention on International Trade in Endangered Species of Wild Fauna and Flora)?
Sterile or modified insects for area-wide control programmes	The Food and Agriculture Organization of the United Nations (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 intergovernmental agreements? Who can oversee use of insects not treated with irradiation in a role similar to FAO and the IAEA in their historic oversight of irradiated insects? What would need to change in the terms of authority to facilitate this, and would any other entities be better suited than FAO/IAEA?
Companion insect and educational use	What form of oversight or coordination would ensure that rare species and marginal habitats are not over-exploited? What measures can be put into place to reduce the probability of escape or accidental release into the environment? Which authorities should oversee this trade?
Viable insects surviving for at least the first generation at the receiving site	
Modified populations of live insects	CBD, WOAH, IPPC – Will modifications to traded insects be evaluated based on the resulting change in risk (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 to provide guidance, or is it only a matter of 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? WOAH – Is additional guidance needed to ensure insect-based animal feed is safe for consumption?
Dead insect samples or collectables	WOAH – Is there any animal disease that remains viable after the insect is no longer viable and that could be spread mechanically? What actions could manage that? Should the safety of non-viable samples for reference collections, hobby collectors, etc., be overseen by a different organisation?

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Un cadre commun, fondé sur les risques, est-il envisageable pour les décisions relatives au commerce d'insectes vivants ?

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Résumé

À l'occasion d'une réunion d'experts, un réseau de chercheurs travaillant sur l'expédition d'insectes vivants a produit un ensemble d'articles traitant des questions liées au transport des insectes vivants. Ce réseau est diversifié et représente un large éventail d'intérêts privés et de programmes de lutte biologique à grande échelle menés par les pouvoirs publics, en plus du secteur de la recherche biomédicale et de nombreux acteurs intervenant dans des applications de plus petite envergure relevant de la recherche, de l'enseignement ou du secteur privé. Un grand nombre d'espèces d'insectes sont transportées en toute sécurité avec un niveau de risque minimal, y compris lors des fréquentes expéditions internationales. Un exemple de ces expéditions régulières concerne l'espèce la plus utilisée par la recherche biomédicale en tant qu'organisme modèle, à savoir *Drosophila melanogaster*. Les exemples réussis d'expéditions à grande échelle provenant de fournisseurs d'agents de lutte biologique et de pollinisateurs produits par le secteur privé offrent également un relevé documenté des diverses catégories d'expéditions à faible risque pour des livraisons d'insectes vivants en grandes quantités et répondant à des normes de qualité élevées. Les décideurs politiques devraient pouvoir accéder à plus d'informations (à travers des publications ou des articles officiels) décrivant en détail les risques réels associés aux insectes eux-mêmes ou à leurs contaminants éventuels, et proposer en connaissance de cause des niveaux de gestion proportionnels à ces risques. La récolte d'insectes prélevés directement de la nature peut être dommageable aussi bien pour les environnements source que pour ceux de destination. Plusieurs cadres fondés sur le risque intègrent désormais les insectes dans leurs directives. Par ailleurs, nombre d'organismes internationaux de coordination ont acquis une expérience dans l'élaboration de lignes directrices face à ces risques. Il serait bénéfique pour toutes les parties prenantes de disposer d'une vue d'ensemble intégrée des directives applicables aux expéditions d'insectes, qui recense les différents types de risque et leurs ordres de grandeur sans se prononcer sur une approche unique qui nécessiterait une adhésion universelle. Ni les propositions visant à gérer l'incertitude ni l'insuffisance des données disponibles sur les expéditions d'insectes en petits nombres ou occasionnelles ne doivent perturber les échanges commerciaux d'insectes vivants en grandes quantités, échanges qui participent aujourd'hui aux objectifs stratégiques de nombreux secteurs.

Mots-clés

Analyse du risque – Commerce international – Insecte – Services de messagerie – Traités et organisations intergouvernementaux.

¿Puede haber un sistema común basado en el riesgo para adoptar decisiones relativas al comercio de insectos vivos?

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Resumen

Una red de científicos relacionados de un modo u otro con el transporte de insectos vivos mantuvo un encuentro y generó una serie de artículos en torno a la cuestión. En la red, muy heterogénea, convergen desde intereses comerciales

de gran calado hasta programas públicos de lucha biológica en grandes territorios, pasando por la investigación biomédica y por numerosas aplicaciones de menor dimensión en ámbitos como la investigación, la enseñanza u otros usos privados. Muchas especies de insectos cuentan con un buen historial de seguridad en el transporte, presentan un riesgo mínimo y son expedidas a menudo de un país a otro. Buen ejemplo de ello son los envíos sistemáticos de ejemplares de *Drosophila melanogaster*, que es el insecto utilizado con más frecuencia como organismo modelo en la investigación biomédica. Otro precedente de envíos voluminosos cuyo transporte y entrega se ajusta a los más exigentes criterios de calidad lo sientan las remesas de grandes cantidades de polinizadores y agentes de control biológico remitidos por proveedores comerciales. Los responsables de adoptar decisiones deben disponer de más y más detallada información (publicaciones o documentos oficiales) sobre los riesgos reales derivados de los propios insectos o sus posibles contaminantes para proponer a partir de ahí medidas de gestión proporcionadas. Los perjuicios ambientales pueden darse tanto en origen (cuando hay captura salvaje de insectos, o sea recolección directa en el medio) como en destino. Hay varios sistemas de determinación del riesgo que incluyen a los insectos y también existen diversos organismos de coordinación internacional que ya tienen experiencia en sentar pautas sobre los riesgos en la materia. Todos los interlocutores del sector se beneficiarían de una visión global e integrada del transporte de insectos, que remita a diferentes tipos de riesgo y categorías de magnitud, sin necesidad de buscar un sistema único que exija consenso universal. Las propuestas para gestionar la incertidumbre y la falta de información en el caso de envíos infrecuentes o de pequeñas dimensiones, por ejemplo, no deben interferir en el transporte de grandes cantidades de insectos vivos, que ya está sirviendo a objetivos estratégicos en varios sectores.

Palabras clave

Análisis del riesgo – Comercio – Insecto – Servicios de mensajería – Tratados y organizaciones intergubernamentales.

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