BOOKS & ARTS

Insects of war, terror and torture

Whether natural or intentional, the security threats posed by arthropods — from assassin bugs to disease-carrying pests — should be of concern to us all, explains **Kenneth J. Linthicum**.

Six-Legged Soldiers: Using Insects as Weapons of War
by Jeffrey A. Lockwood
Oxford University Press: 2008. 400 pp.
£14.99, $27.95 (hbk)

From plagues to malaria transmission, insects and other arthropods have threatened military and civilian populations throughout human history. The success or failure of military campaigns has frequently been determined by correctly anticipating the risks of diseases borne by insects and other vectors, and then mitigating against them. Recognizing this, the world's armed forces employ a large cadre of scientists with expertise in entomology or preventive medicine.

Six-Legged Soldiers describes many potential or actual uses of insects as offensive weapons during the past 100,000 years, with an emphasis on the past 300 years. Entomologist Jeffrey Lockwood describes how stinging and highly toxic insects and other arthropods have been used to cause pain and suffering to foes — from the use of bees and hornets by early humans to attack enemies, to the assassin bugs used by an Uzbek emir for torture in the early 1800s.

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Tiny terrorists: the assassin bug (above) and the Colorado potato beetle, or 'Amikäfer' (left), touted as a US cold-war weapon in 1950s East Germany.

It is often difficult to determine whether an insect-borne threat is a natural occurrence or an intentional act. As an example, Lockwood explains how six of the ten plagues that struck Egypt, as described in the Old Testament book of Exodus, may have been caused by natural phenomena involving insects. As natural vectors of disease, insects affected many wars in recorded history, including Napoleon's campaigns, the American Civil War — in which two-thirds of the 500,000 soldiers who died were killed by diseases such as malaria and yellow fever — and the First World War.

In the Second World War, insects were developed as biological weapons; the infamous Japanese Unit 731 programme had plans to produce 5 billion plague-infected fleas per year. During the cold war there was an unprecedented level of research and development into using insects as biological warfare agents. Lockwood discusses accusations and activities concerning Korea, Vietnam, Cuba, the Soviet Union and the United States. He ends with a look to the future uses of insects in warfare, including, potentially, agroterrorism, bioterrorism, insects as sentinels and detectors, and insect cyborgs.

Biological warfare is typically developed as clandestine operations. Although it may be used in propaganda campaigns to create fear among the enemy, it is poorly documented. The secret nature of this morally repugnant form of warfare is maintained to eliminate evidence that could be used by prosecutors in future international war-crimes tribunals. Lockwood relies on personal interviews and declassified and previously published documents, and he presents a wide array of accounts. He is carefully circumspect, realizing that some of the accounts may be untrue or partially true, and he qualifies his statements accordingly.

Lockwood takes care to describe accurately the scientific nomenclature of the insect taxa he is discussing, whether it be the mosquito vector of dengue fever, *Aedes aegypti*; a putative tick vector of haemorrhagic fever in the family Ixodidae; or the Mediterranean fruitfly *Ceratitis capitata*.

Six-Legged Soldiers highlights the vulnerability of the United States and other Western nations to terrorist attacks. It draws from the 1999 introduction of West Nile virus into the United States, where the disease, of unknown origin, spread from New York to California in five years. A potentially greater threat is posed to human and animal health by Rift Valley fever, another mosquito-borne disease of sub-Saharan Africa. Lockwood states that "the prognosis for curtailing Rift Valley fever by suppressing its vectors is poor", and implies that US public-health and agricultural communities are not addressing the threat. However, he fails to recognize the efforts that are underway. Outbreaks in Africa are being predicted by scientists at the US Department of Defense, NASA and the US Department of Agriculture, allowing international bodies and individual nations to enhance global vigilance. US federal, state and local agencies are developing research

agendas and formulating control strategies for vectors of Rift Valley fever.

Lockwood describes a history of collaborations in the United States between the defence department and the Department of Agriculture to develop insect-based biological weapons extending back to the Second World War. Yet he does not mention other significant collaborative efforts to protect military and civilian populations from insect bites and disease transmission, such as the development in the late 1940s of the most effective and widely used insect repellent, DEET, and the Deployed War-Fighter Protection (DWFP) programme started in 2004 to produce new insect repellents and control products and technologies to protect deployed troops. The DWFP programme has produced more than 60 peer-reviewed scientific publications including the application of RNA interference technology to potentially develop a new class of insecticide that is safe to non-targeted species. Given the paucity of effective vector-borne disease mitigation tools, the products developed in the DWFP programme will directly reduce disease.

Six-Legged Soldiers is an excellent account of the effect that arthropod-borne diseases have had on warfare. The discussions of how we are prepared, or not, for future threats from military operations, accidental introductions or bioterrorist events are pessimistic. The book highlights the need for further research to prevent, detect and mitigate vector-borne disease introductions, and to prevent globalization of entomological threats. This book will inspire readers to understand those threats and prepare new methods to combat them. ■

Kenneth J. Linthicum is director of the USDA Agricultural Research Service, Center for Medical, Agricultural, and Veterinary Entomology, Gainesville, Florida 32608, USA.
e-mail: kenneth.linthicum@ars.usda.gov

Tapping out a message

Vibrational Communication in Animals
by Peggy S. M. Hill
Harvard University Press: 2008. 272 pp.
$39.95, £25.95, €30.00

Coding and Redundancy: Man-Made and Animal-Evolved Signals
by Jack P. Hailman
Harvard University Press: 2008. 272 pp.
$39.95, £25.95, €30.00

In animal-communication research, the understanding of group behaviour is important. The development of the framework for communication networks 15 years ago has provided the field with a great conceptual advance. It takes into account that many signalling interactions do not only involve a sender and a receiver — bystanders may also eavesdrop to gain valuable information about the relative strength, aggressiveness or levels of cooperation in potential opponents or partners. Consequently, signallers may adjust their behaviour to address eavesdroppers as well as the main recipient. Such audience effects can increase levels of both aggression and cooperation in communication networks, which are seen in many diverse species across a wide range of taxa.

This framework concept links to the field of animal cognition. Animals in a group must keep track of relationships between group members to form the most beneficial coalitions, but the complexity of following these relationships increases exponentially with group size. Baboon females, for example, know both the relative rank and the matrilineal membership of all other group females. In humans, cooperation between individuals in a large group may yield benefits through indirect reciprocity — eavesdroppers are more willing to help individuals who have contributed to the public good. Two new books remind us that the physical aspects of animal communication are also important.

In *Vibrational Communication in Animals*, animal behaviourist Peggy Hill provides an up-to-date overview of this field. Because the field of vibrational communication deals with a communication channel that is alien to our own species, research can be both frustrating and exciting. Many case studies in the book read like lawsuits in which a combination of indices provides a compelling case in the absence of more direct evidence. That may be caused by the complex technical equipment required to measure the propagation of signals in the material being vibrated. But the rest of Hill's work is a beautiful case of integrative biology, highlighting anatomical and neurophysiological studies that describe the organs that receive and emit signals, and the behavioural studies needed to document that a species uses vibrational information in its communication. Owing to the introduced dichotomy between vibrational and auditory communication, scientists must exclude the auditory route as the primary information channel to conclude that animals use vibrational signals.

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Rat-a-tat: banner-tailed kangaroo rats drum to their own beat.

Hill makes a strong case that vibrational communication is widespread in animals. She uses an impressive collection of examples drawn across taxonomic groups. Particularly enjoyable is the case of the banner-tailed kangaroo rat — individuals develop their own signature foot-drumming, which they keep for life unless a new similarly drumming neighbour warrants adjustments to guarantee individual recognition. Another amazing story is about treehoppers, in which kin groups of these plant-eating insects use vibrational signals to coordinate their movements from a depleted resource to a better one — a wonderful example of groups acting as information centres.

A take-home message of Hill's book is that there are many unresolved questions that warrant more research. Signals could be varied to test if they still convey meaning, or to show that encoded information is simple. A new framework might predict under which circumstances vibrational communication will be selected over other means. A better understanding may also yield practical benefits: there are many anecdotes about certain animal species that can sense earthquakes or tsunamis and take evasive action. Overall, the book demonstrates beautifully the strength of research on animal behaviour, the appreciation of the great diversity of species and their adaptations to their specific ecological niches.

In *Coding and Redundancy*, zoologist Jack Hailman classifies man-made and animal-evolved signals according to the information coded within them. Key attributes include the type of information — binary, multivalued or multivariate — and the level of redundancy. Hailman's approach is novel, and his writing is easy to follow. Because the goal of the book is to classify, it does not say much about recent studies of animal communication. Instead,