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Research Article

Biosecurity interceptions of coconut rhinoceros beetle *Oryctes rhinoceros*

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Abstract

We report biosecurity interceptions of *Oryctes rhinoceros* in Australia, New Zealand, Guam, United States, and other jurisdictions to provide the first such published assessment for this highly invasive species. Between 2003 and July 2023 New Zealand found *O. rhinoceros* 13 times. Between 2002 and July 2023 Australia found *Oryctes rhinoceros* 14 times. Since 2017 inspections in Guam detected individuals twice. Between 2003 and 2014, beetles were found eight times at ports in the United States. No credible interceptions were made in the European Union. Four other intercepts were reported from two other jurisdictions. There were very little commonalities among the intercept data. All but one detection were of adults, and of the 14 adults that were sexed, eight were female and six were male. From the Australian data, which included month of detection, there was no seasonality associated with detections. Detections were associated with a broad array of commodities or situations. *Oryctes rhinoceros* appears to be a generalist passenger, being accidentally transported by a wide variety of means at any time. This finding indicates that there is little possibility of focusing on any specific commodity, packaging, vessel, or season to detect accidental transport of this species. Instead, biosecurity vigilance is required on all goods and vessels arriving at, or leaving, destinations.

Key words: CRB, commodities detections, eradication, incursion, invasive, Pacific, transport

Introduction

The coconut rhinoceros beetle, *Oryctes rhinoceros*, is native to eastern Asia, but has been accidentally dispersed to many places throughout the world where it is a key pest of coconut and oil palm (Bedford 1980). As an example of its dispersal abilities, it was first reported in the Pacific from Samoa in 1909. Of the 21 jurisdictions in the region, the only ones that still remain free of it are the Cook Islands, French Polynesia, Federated States of Micronesia, Kiribati, Nauru, Niue, Pitcairn Islands, and Tuvalu (Paudel et al. 2022). Most recently it has established in the Republic of Marshall Islands (Roland Quitugua *pers. comm.*). It has also recently been found on the Hawaiian islands of Kaua'i and Hawai'i (HDOA 2023) and reportedly too in Mexico (Quiroz et al. 2017; Jackson et al. 2022). Despite the beetle

being subject to eradication attempts in almost all places it has arrived to date, there is only one purported record of eradication being achieved, being from Niuataputapu, Tonga, back in 1931 (Lever 1979), but no details were provided about the eradication. Clearly, preventing its accidental transport is more effective than attempting to extirpate or manage it following its establishment in a novel location.

Effectively preventing new incursions of any species requires the ability to either prevent it from infesting goods to be transported, detecting it within goods at a source location prior to transport, or detecting it as soon as possible when it arrives at a destination prior to it escaping into the environment. Such work is aided by understanding the pathways and potential associations with commodities by which the species is being dispersed (Lee et al. 2020; Kachigunda et al. 2023), and any other patterns such as seasonality of dispersal (e.g., Brown marmorated stink bug, DAFF (2023)) and transportation differences among life stages (e.g., predominantly eggs and larvae being transported in agricultural commodities for lepidopteran pests instead of adults, European Commission (2023)). Although there are some published interceptions of *O. rhinoceros* and the goods it was associated with for accidental transport (Lever 1979; Crowe 2002; Quiroz et al. 2017), there has not yet been a systematic compilation of such interception records. Here we report biosecurity interceptions of *O. rhinoceros* in goods or vessels either about to be transported or recently transported from numerous jurisdictions to provide the first such published assessment for this highly invasive species. We discuss the implications of the findings in terms of improving biosecurity and inspections to prevent further dispersal of this species.

Materials and methods

Data were sourced from four databases. Data from Australia were obtained from the Incidents Client database on 3 July 2023, with the oldest date accessible being 2002. Data from New Zealand were sourced from the Ministry of Primary Industries' Laboratory Information Management System database on 18 July 2023, containing data from 2003. Data from the European Union and Switzerland were sourced from the Europhyt database (European Commission 2023) on 29 August 2023, with data being from 2005 to 2020. Data from US Defense of pre-departure biosecurity cleanliness inspections on Guam and Rota were sourced from the contractor's biosecurity inspection database (CSU CEMML: Colorado State University's Center for Environmental Management of Military Lands) on 4 September 2023, with data spanning from September 2017 to present. The data from CSU CEMML was additionally supplemented after we were informed of another find on 2 September 2023 that was formally identified and reported on 28 September 2023. Ideally data would have been sourced from databases of other jurisdictions to generate a greater analysis, but we were unable to

do so either because we were not able to obtain data from associated biosecurity databases (e.g. Fiji), or such databases do not exist despite the occurrence of inspections (e.g. Guam's civilian ports of entry and cargo warehouses). Therefore, to increase the data, additional general web-searches were conducted on 24 September 2023 using the search terms "*Oryctes rhinoceros* interception", "CRB interception", and "Coconut rhinoceros beetle interception" to find other reported interceptions not necessarily associated with a biosecurity database. Ultimately, we considered that the data obtained were sufficient to give this first insight into the detected dispersal of *Oryctes rhinoceros* by human transport. Analyses were basic summaries of the data.

Results

Between 2003 and July 2023 New Zealand found *O. rhinoceros* in imported goods or vessels recently arrived from overseas 13 times, and between 2002 and July 2023 Australia found *O. rhinoceros* 14 times (Table 1), with all presumably being from visual inspections. Inspections in Guam using a detector dog found the first *O. rhinoceros* beetle in August 2023 after just over five years of searches (KUAM 2023), and a second in September 2023. The Europhyt database reported the finding of two adults in June 2011, presumably from visual inspections. The goods these two adult specimens were associated with were classed as "plants intended for planting", and the source locations was the Dominican Republic. However, although the Dominican Republic has been modelled as climatically suitable for *O. rhinoceros* (Hao et al. 2022), *O. rhinoceros* is not reported to occur there (CABI 2023; EPPO 2023), so we consider this interception to be a potential misidentification and it is therefore not considered further. Eight records from the United States port interception database (PestID 2017) ranging from 2003 to 2014 were found published in a pest risk analysis (Kumar and Bigsby 2018). Four other intercept records were found not associated with databases, presumably from visual inspections

There were very little commonalities among the intercept data. All but one of the interceptions were of adults, and of the 14 adults that were sexed, eight were female and six were male. From the Australian database, which included month of detection, there was no seasonality associated with detections, with *O. rhinoceros* being found to date in all months except for July and October. Detections were associated with a broad array of commodities or situations. From the databases, *O. rhinoceros* was found associated with imported bananas seven times, with aircraft passenger luggage seven times, and nine times in other commodities of dried Beche De Mer, plastic bibs, taro, cut flowers, wood and other produce and used flow meters. From the non-databased detections, the *O. rhinoceros* was also found in a styrofoam box containing tissue culture flasks, with palm furniture, and in packaged garden soil. From the databases, detections were made five times associated with sea or air freight containers, and three times

Table 1. Biosecurity interceptions of *O. rhinoceros* in goods or vessels either about to be transported or recently transported. Blank data indicate that the data were not recorded by the source. Source codes are: LIMS Laboratory Information Management System; IC Incidents Client database; CSU CEMML Colorado State University's Center for Environmental Management of Military Lands.

Country	Date	Location	Carrier/commodity	Sex	Number	Life stage	Status	Source
New Zealand	2003	Post Border	Banana	Female	1	Adult	Dead	LIMS
New Zealand	2003	Post Border	Banana	Female	1	Adult	Alive	LIMS
New Zealand	2003	Border	Banana	Female	1	Adult	Alive	LIMS
New Zealand	2005	Post Border	Banana	Male	1	Adult	Alive	LIMS
New Zealand	2007	Post Border	Banana		1	Adult	Alive	LIMS
New Zealand	2009	Post Border	Unknown	Female	1	Adult	Alive	LIMS
New Zealand	2009	Post Border	Banana packaging box	Male	1	Adult	Dead	LIMS
New Zealand	2009	Vessel Survey	Vessel		1	Adult	Alive	LIMS
New Zealand	2011	Post Border	Banana	Female	1	Adult	Alive	LIMS
New Zealand	2015	Border	Baggage	Male	1	Adult	Alive	LIMS
New Zealand	2016	Post Border	Passenger	Female	1	Adult	Dead	LIMS
New Zealand	2017	Border	Air can/Container	Female	1	Adult	Alive	LIMS
New Zealand	2023	Border	Taro	Male	1	Adult	Alive	LIMS
Australia	May 2007	Border	Shipping container (External)			Adult		IC
Australia	February 2009	Border	Military vessel			Adult		IC
Australia	April 2009	Border	Shipping Container			Adult		IC
Australia	August 2009	Border	Baggage			Adult		IC
Australia	October 2010	Border	Personal Effects Baggage			Adult		IC
Australia	March 2011	Border	Personal Effects Baggage			Adult		IC
Australia	November 2016	Border	Personal Effects Baggage			Adult		IC
Australia	May 2017	Border	Timber pallet			Adult		IC
Australia	September 2018	Post Border	Inside a box of plastic bibs		1	Adult	Dead	IC
Australia	June 2019	Border	Aircraft Cabin		1	Adult	Dead	IC
Australia	June 2020	Border	Air can (external), cut flowers			Adult		IC
Australia	January 2021	Border	Dried Beche De Mer			Adult		IC
Australia	September 2021	Border	Inside timber crate with used flow meters	Female		Adult	Alive	IC
Australia	December 2022	Border	Shipping Container (external)			Adult	Alive	IC
Australia	1995-2000	Border	Aircraft cargo hold			Adult		Crowe 2002
Australia	1995-2000	Border	Styrofoam box with tissue culture flasks			Adult		Crowe 2002
USA	January 2003	Border	Wood products (sea cargo)		2	Alive	USA	Kumar and Bigsby 2018
USA	January 2003	Border	coconut wood products (sea cargo)		3	Alive	USA	Kumar and Bigsby 2018
USA	October 2003	Border	airport, miscellaneous		1	Alive	USA	Kumar and Bigsby 2018
USA	September 2010	Border	cut flowers		1	Alive	USA	Kumar and Bigsby 2018
USA	December 2011	Border	airport baggage		1	Alive	USA	Kumar and Bigsby 2018
USA	August 2012	Post Border	dried banana		1	Alive	USA	Kumar and Bigsby 2018
USA	November 2013	Border	airport, miscellaneous		1	Alive	USA	Kumar and Bigsby 2018
USA	February 2014	Border	miscellaneous		1	Alive	USA	Kumar and Bigsby 2018
Guam	August 2023	Pre-transit	Vehicle	Male		Adult	Alive	CSU CEMML
Guam	September 2023	Pre-transit	Aircraft wheel well	Male		Adult	Alive	Glenn Dulla *pers. comm.*
Guam	April 2016	Pre-transit	Packaged garden soil		numerous	Larvae	Alive	Moore et al. 2016
Mexico	June 2014	Border	Palm furniture		1	Adult	Alive	Quiroz et al. 2017

on transport vessels including within an aircraft cabin. From the non-database detections, there were three instances of association with a vessel, one being an aircraft cargo hold, one being an aircraft wheel well, and the

other being a vehicle. Of all records, of the 21 with data, the beetles found were alive in 16 instances and dead in the remaining five instances. The only interception that involved larvae, and also coincidentally found multiple individuals, involved packed garden soil.

Discussion

The intercept data demonstrated that *O. rhinoceros* appears to be a generalist passenger, being accidentally transported by a wide variety of means at any time. This finding agrees with the prior incidental reports of this species being found within a broad array of goods and transport methods, which even includes logs floating in the ocean (Lever 1979). This also indicates that there is little possibility of focusing on any specific commodity, packaging, vessel, or season to detect accidental transport of this species. Instead, biosecurity vigilance is required on all goods and vessels arriving at, or leaving, destinations. At most, the beetle was continually associated with bananas arriving in New Zealand from 2003 to 2011, being from a single source jurisdiction (data not presented). The lack of interceptions for more than a decade since 2011 indicates that this infestation risk was somehow resolved, but it is unknown what action may have been taken (Disna Gunawardana *pers. comm.*). The beetle was also found numerous times within aircraft passenger baggage as well various airplane spaces (cabin, cargo hold, wheel well), and a vehicle. Exactly how, when and why individual beetles are opportunistically gaining access to such locations is unclear, but clearly this beetle can be readily dispersed by such means.

Adults were clearly the life form most likely to be accidentally dispersed, and both sexes were capable of being accidentally dispersed. However, given that almost all detections of adults involved single individuals, unless a female was gravid a new incursion would require multiple successful transport opportunities (ultimately of both sexes) to be successful. However, this was not the same for larvae. When packaged soil was found infested with *O. rhinoceros* larvae, up to 57 individuals were found within a single bag and multiple bags were infested (Moore et al. 2016). A single such incursion would unequivocally result in successful establishment if the receiving environment was suitable.

Interception data on CRB summarised here likely represents a mere fraction of all official intercepts, with many more either not being publicly available, not published, not recorded adequately, being recorded in different languages, or just difficult to find on the internet. For example, the China Yearbook of Port Quarantine Inspection Online Publishing Database listed the first ever interception of the coconut rhinoceros beetles at the Yancheng Port (Port Quarantine Inspection 2019). However, we did not include this reported interception in the overall interception counts as the scientific name "*O. rhinoceros*" was not provided (i.e., only the generic common name "coconut rhinoceros beetle" was provided) and only partial access to the

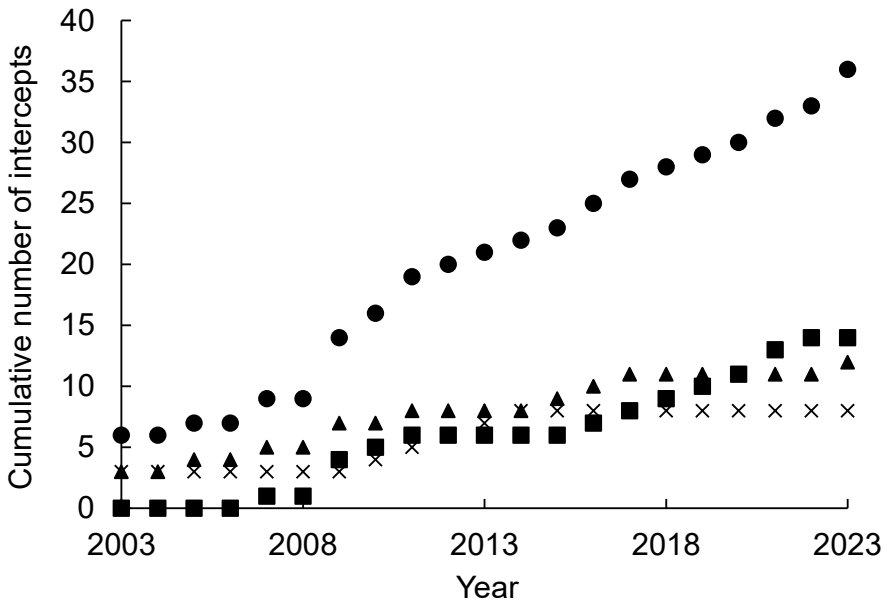

Figure 1. Cumulative number of *O. rhinoceros* interceptions for the jurisdictions with biosecurity databases we could access, being Australia (squares) and New Zealand (triangles) as well as records from USA provided in Kumar and Bigsby (2018) and all combined with other records from Guam (circles).

database was possible. That there were no credible interceptions in Europe, but numerous within the Pacific, is likely reflective of relative trade of those destinations with places infested with *O. rhinoceros*.

The combined interception data (Figure 1) displayed a near constant rate of propagule pressure, with detections (predominantly for New Zealand and Australia) occurring at 1.2 per year. We argue that it would be logical to assume that a similar propagule pressure would be occurring for other jurisdictions within the Asia-Pacific region, and therefore, it should not be surprising that *O. rhinoceros* has been so successful at dispersing to so many locations outside of its native range, and continues to do so (Jackson et al. 2022; Paudel et al. 2022; HDOA 2023). If this pattern of detections is indeed reflective of *O. rhinoceros* dispersal to other jurisdictions throughout the Pacific, then this highlights the need for biosecurity procedures to be increased in those few Pacific jurisdictions that remain free of this species, as well as in other climatically suitable regions (e.g., Africa, Americas; see Aidoo et al. 2022). Only enhanced biosecurity and public awareness will prevent further incursions of this generalist invader.

Authors' contribution

BH conceived the idea. BH, AB and WT collated the data, analysed the data and drafted the manuscript. All authors edited and approved the final manuscript.

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Data accessibility

All data are supplied with this publication.

References

Aidoo OF, Ding F, Ma, T, Jiang D, Wang D, Hao M, Tettey E, Andoh-Mensah S, Ninsin KD, Borgemeister C (2022) Determining the potential distribution of *Oryctes monoceros* and *Oryctes rhinoceros* by combining machine-learning with high-dimensional multidisciplinary environmental variables. *Scientific Reports* 12: 17439, https://doi.org/10.1038/s41598-022-21367-1

Bedford GO (1980) Biology, ecology and control of palm Rhinoceros beetles. *Annual Review of Entomology* 25: 309–339, https://doi.org/10.1146/annurev.en.25.010180.001521

Crowe B (2002) Quarantine Apprehends Dangerous Invaders - a recent account of some major finds in Queensland. *Queensland Entomological Society* 30: 109–126

Hao M, Aidoo OF, Qian Y, Wang D, Ding F, Ma T, Tettey E, Ninsin KD, Osabutey AF, Borgemeister C (2022) Global potential distribution of *Oryctes rhinoceros*, as predicted by boosted regression tree model. *Global Ecology and Conservation* 37: e02175, https://doi.org/10.1016/j/gecko.2022.e02175

Jackson TA, Rincón MN, Villamizar LF, Paudel S (2022) Social media posts suggest that coconut rhinoceros beetle has established in the Western hemisphere. *Journal of Applied Entomology* 147: 19–22, https://doi.org/10.1111/jen.13083

Kachigunda B, Coupland GT, Mengersen K, Perera DI, van der Merwe J, McKirdy S (2023) A systems approach to biosecurity pays off: a case study investigating introduction pathways and interceptions of non-indigenous species at a biosecurity border. *Biological Invasions* 25: 2849–2871, https://doi.org/10.1007/s10530-023-03077-5

Kumar S, Bigsby K (2018) Pathway Analysis for the Introduction of Coconut Rhinoceros Beetle (*Oryctes rhinoceros* L.) into the Conterminous United States, Puerto Rico, and the U.S. Virgin Islands. United States Department of Agriculture Animal and Plant Health Inspection Service Plant Protection and Quarantine, Raleigh NC, 36 pp

Lee CC, Weng YM, Lai LC, Suarez AV, Wu WJ, Lin CC, Yang CCS (2020) Analysis of recent interception records reveals frequent transport of arboreal ants and potential predictors for ant invasion in Taiwan. *Insects* 11: 356, https://doi.org/10.3390/insects11060356

Lever RJAW (1979) Pests of the Coconut Palm. Food and Agriculture Organization of the United Nations, 190 pp

Moore A, Quitugua R, Iriate I, Melzer M, Watanabe S, Cheng Z, Barnes JM (2016) Movement of packaged soil products as a dispersal pathway for coconut rhinoceros beetle, *Oryctes rhinoceros* (Coleoptera: Scarabaeidae) and other invasive species. *Proceedings of the Hawaii Entomological Society* 48: 21–22

Paudel S, Marshall SDG, Richards NK, Hazelman G, Tanielu P, Jackson TA (2022) Coconut Rhinoceros beetle in SamoaL Review of a century-old invasion and prospects for control in a changing future. *Insects* 13: 487, https://doi.org/10.3390/insects13050487

Port Quarantine Inspection (2019) China Online Publishing Database Yearbook 2019. Jiangsu People's Publishing House. Office of the Local Chronicles Compilation Committee of Dafeng District, Yancheng City, 101 pp

Quiroz EJ, Morales OM, Ramírez OT, Villalobos GG, Alarcón MEG, Nolazquez OC (2017) First intercept of the Asiatic coconut rhinoceros beetle *Oryctes rhinoceros* (Linnaeus, 1758) in Mexico. *Revista Mexicana de Ciencias Forestales* 8: 99–105, https://doi.org/10.29298/rmcf.v8i39.46

Web sites and online databases

CABI (2023) Compendium. https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.37974 (accessed 30 August 2023)

DAFF (2023) https://www.agriculture.gov.au/biosecurity-trade/import/before/brown-marmorated-stink-bugs (accessed 18 September 2023)

EPPO (2023) EPPO Global Database. https://gd.eppo.int/taxon/ORYCRH/distribution (accessed 30 August 2023)

European Commission (2023) https://food.ec.europa.eu/plants/plant-health-and-biosecurity/europhyt/interceptions (accessed 29 August 2023)

HDOA (2023) Coconut rhinoceros beetles detected on Kauai. https://hdoa.hawaii.gov/blog/main/nr23-11crbonkauai (accessed 7 October 2023)

KUAM (2023) https://www.kuam.com/story/49398172/detector-dog-team-prevents-coconut-rhino-beetle-spread-to-marshall-islands (accessed 18 August 2023)

PestID (2017) Agricultural Quarantine Activity Systems (AQAS) Pest Report. Pest Identification Database (PestID). United States Department of Agriculture, Animal and Plant Health Version 2 March 26, 2018 21 Inspection Service, Plant Protection and Quarantine. https://aqas.aphis.usda.gov/aqas/HomePageInit