Do changes in volcanic activity promote the diversity of initial processes in oceanic island ecosystems? : Biotic changes associated with the eruption of Nishinoshima Island

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On Nishinoshima in the Ogasawara Islands, eruptions recurred over a decade following the 2013 eruption, the first in 40 years. The new island formed by the eruption completely covered the previous island due to lava flow. At the late stage of the fourth episode in 2019 to 2020, the eruption style changed to a violent Strombolian, turning the previously exposed lava surface into one thickly covered by volcanic clasts. The biota of Nishinoshima was severely impacted by these volcanic activities, with many species that had constituted the ecosystem facing extinction, resulting in the island's ecosystem being almost entirely reset.
Oceanic islands, such as the Galápagos Islands, the Hawaiian Islands, and the Ogasawara Islands, which emerged from the activity of undersea volcanoes far from any continent, have developed unique biota through the arrival of biased species and subsequent evolution. What kinds of species invasions, extinctions, and changes in interspecies relationships exist during initial phase of these islands, leading to the maturation of their endemic characteristics? Nishinoshima is the only oceanic island on the present Earth where the entire process of ecosystem succession can be recorded and verified from the starting point on an isolated island far from surrounding mainland. Through landing surveys in 2019, 2021, 2022, and 2025, and remote surveys using monitoring equipment in 2021, 2023, and 2024, it has been revealed that significant changes have emerged in the terrestrial biota within just five years.
Until 2019, almost the entire island was covered in lava, preventing plants from establishing on the new lava surface due to its lack of water retention capacity. Alternatively, in seabird nesting sites, decomposers such as earwigs, which digest carcasses and faeces, and parasites including ticks that infest seabirds, inhabit in high densities. Seabirds and the organic materials they deliver from the ocean contribute significantly to the terrestrial ecosystem. Even after the fourth eruption, decomposer arthropods consistently inhabit each seabird nesting site. Contrary to general succession, in the early stages of an oceanic island's ecosystem, the seabirds, as predators, may act as pioneers. Subsequently, decomposers establish the soil, followed by plants and then herbivores, in that sequence.
On the other hand, the 2025 landing survey confirmed the invasion of bryophytes and ferns in deeply eroded gullies within the volcaniclastic deposits, for the first time since all vascular plants disappeared during the fourth phase of eruptions. Six species of algae were identified from traces of pools at the base of cliffs. This represents a definite increase from the single species at one location in 2021, with numerous patches now scattered throughout. The erosion of the ash-covered terrain after deposition has facilitated the retention of high humidity, revealing the potential for a typical bottom-up ecological succession to establish: plants colonise, followed by herbivores and then predators.
The presence of organisms that struggle to establish themselves under current environmental and biotic conditions has been frequently recorded, such as the arrival of adult moths where their larval food plants are absent, or the inland migration of crab juveniles immediately after metamorphosis. While these organisms inevitably perish in environments unsuitable for reproduction, their repeated cycles of invasion and extinction demonstrate that changes in environmental conditions constantly hold the potential to alter the composition of ecosystems. During the fourth phase of eruptions up to 2020, the original land

surface was completely covered. When volcanic gases increased in 2023, many seabirds temporarily relocated off the island, leading to a drastic decline in their numbers. Not only during the first phase of eruptions up to 2015, but with each subsequent eruption, changes in volcanic activity have significantly impacted the resident biota on Nishinoshima. As the ecosystem matures through repeated cycles of introduction and extinction, the stability and characteristics of the geology are considered to form a crucial foundation.
The initial stages of ecosystem succession may initiate in diverse ways depending on the residual environment and newly emerged environments, shaped by variations in volcanic activity and the diversity of erosion processes. Understanding the diverse characteristics of the land formed by volcanic activity is a crucial key to comprehending the origins of ecosystems.

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