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CHAPTER 22

Malaysia's land snails: Diversity, endemism, and the state of conservation

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Abstract: Malaysia is recognised as a global biodiversity hotspot, but invertebrates remain largely overlooked in the national conservation discourse. We show that land snails are the country's most endangered terrestrial animal group. This is driven by high rates of narrow -range endemism within isolated limestone hills and highland forest ecosystems. Of the 970 land snail species recorded in Malaysia, 40 are currently listed as threatened according to the IUCN. Notably, the 28 species classified as Critically Endangered nearly equal the combined total of critically endangered mammals, birds, and reptiles in Malaysia. The severity of this crisis is underscored by the confirmed global extinction of *Plectostoma sciaphilum* following the complete quarrying of its only known habitat. Facing threats from limestone extraction industry and climate change, the conservation of these overlooked invertebrates requires a multifaceted approach comprising systematic biodiversity documentation, the application of the IUCN Red List of Ecosystems to prioritise limestone hills for protection, and immediate in-situ and/or ex-situ interventions to prevent further extinctions.

INTRODUCTION

Malaysia is known as one of the 17 megadiverse nations and one of the 36 biodiversity hotspots—places on Earth that are both biologically rich and highly threatened (Myers *et al*. 2000). In Malaysia, several large, charismatic, and popular animals have been used as flagship species to highlight conservation issues and to implement conservation action, such as protecting a specific habitat or ecosystem in Malaysia (KATS 2019). While these popular animals represent a broader cause of conservation, many other, less popular animals, especially invertebrates, are typically overlooked in conservation discourse. Furthermore, some of these less-popular animals, particularly many endemic invertebrates with limited distribution ranges, are obligate to small, isolated, and scattered ecosystems such as limestone hills or highland forests, especially mountaintops. Consequently, these unique endemic species and ecosystems that support them are often neglected. When some of these ecosystems are also important in providing irreplaceable raw materials for humans (e.g., limestone hills providing raw material for cement), a conservation crisis can escalate dramatically to a point where it becomes almost impossible to mitigate the degradation of the habitats and prevent the extinction of fauna and flora.

Invertebrates are often overlooked in nature conservation discussions, a pattern reflected in the reports: '*Nature Conservation in Western Malaysia*' (1961) dedicated a chapter only to butterflies, and subsequent report ('*State of Nature Conservation in Malaysia 1991 and 2025*) still focus on only a few taxa (e.g. butterflies, moths, fireflies, and land snails)

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(Figure 1A). This neglect is not deliberate, but stems from the lack of knowledge driven by the sheer hyper-diversity of the group. The largest phylum, Arthropoda, is estimated to be 22 times more species-rich than all vertebrates combined, and Mollusca is 1.5 times richer (Mora *et al.* 2011; Li and Wiens 2023). Hence, the taxonomy of most invertebrate taxa is still far from complete, and their distribution and ecology remain largely unknown.

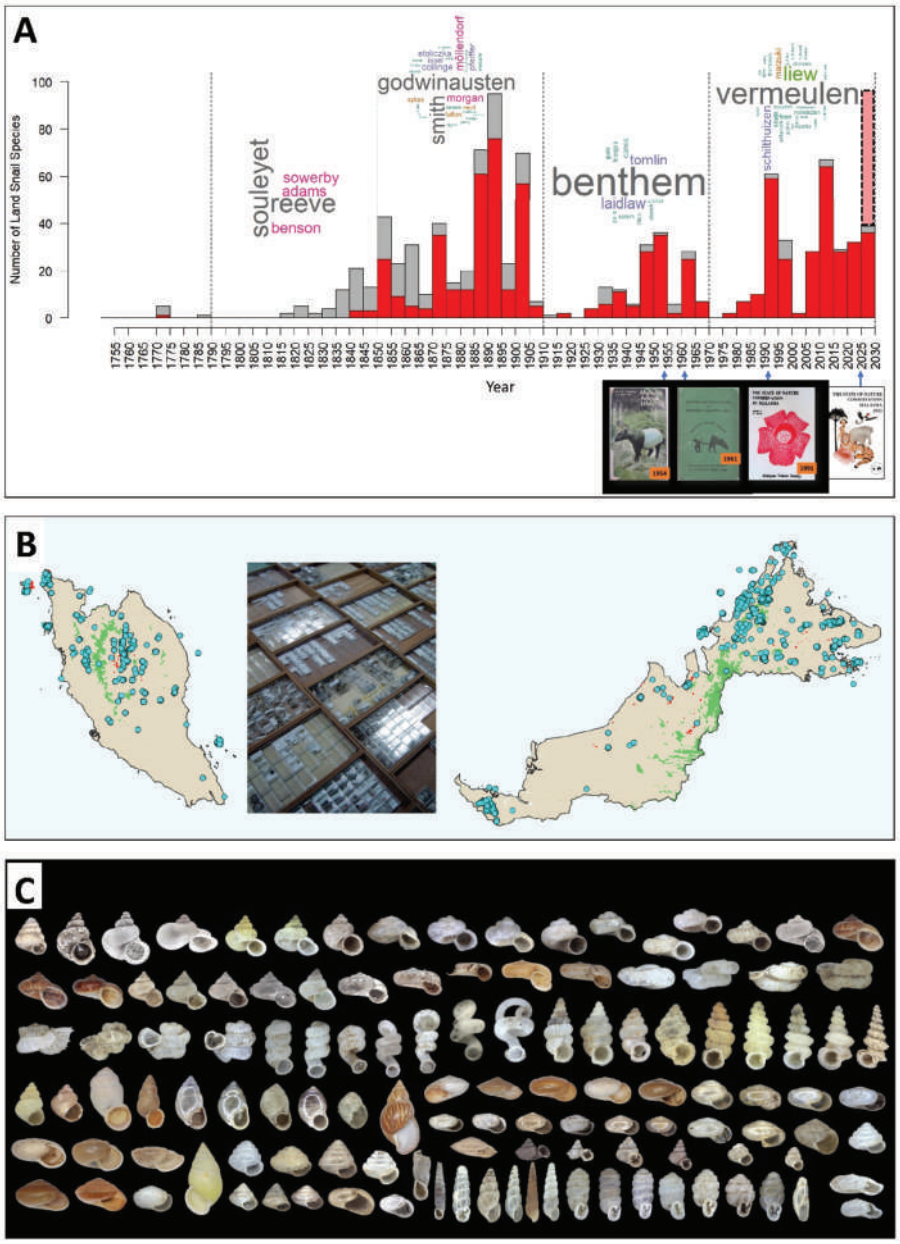

Figure 1. An overview of land snail discovery in Malaysia spanning over two centuries. **(A)** A temporal histogram showing the number of land snail species described (red) or recorded (grey) in Malaysia from 1755 to 2025, with projections to 2030 based on ongoing research (pink dashed bar). Word clouds highlight the main authors of each era and cover images of key SoNC reports (1961, 1991, 2025); **(B)** Distribution of specimen records across Peninsular Malaysia, Sabah, and Sarawak (blue dots) since the 2000s, curated by the BORNEENSIS collection (Universiti Malaysia Sabah) and illustrating the gaps in the land snail surveys; **(C)** Representative morphological diversity of 122 species collected from 12 limestone hills in the Kinta Valley, Perak (Foon *et al.* 2007).

TWO CENTURIES OF LAND SNAIL DISCOVERY AND RESEARCH

Land snail research in Malaysia has a long history, spanning over two centuries, which provides a valuable starting point for understanding their unique diversity and conservation (Figure 1A). Until 1960, there were already around 625 species of land snails recorded, though scattered in literature, in Malaysia (347 in Peninsular Malaysia and 313 species in Sabah and Sarawak, with 32 shared species). Two-thirds (414) of these species were originally described from Malaysia since the mid-19th century by the early explorers, collectors, and scientists. Although their works only covered a relatively tiny portion of Malaysia's landscape, the high species richness of land snails was noticed in isolated ecosystems such as limestone hills and highlands (Tweedie and Harrison 1954; Tweedie 1961). These observations of possibly very high endemism for land snails in limestone ecosystems were also noted in the Nature Conservation in Western Malaysia, 1961 report (Allen 1961; McClure 1961).

In the next three decades, an additional 54 species were added to the list of land snails in Malaysia, bringing the total to 679, with 51 of these originally described from Malaysia (Figure 1A). Although the description of the new species was not as intensive as in previous decades, our understanding of land snail distribution improved significantly. This improvement came when Davison (1990, 1991a) explored more limestone hills in Kelantan and Perak, confirming that the endemism of land snails was extremely high and that many hills possessed their own endemic species, many of which had yet to be discovered. In The State of Nature Conservation in Malaysia 1991 (SoNC 1991), Davison (1991b) stressed that the conservation of these endemic land snails, which are restricted to a single hill or a cluster of hills, cannot be detached from the conservation of the limestone hills themselves, particularly those threatened by quarrying. However, these localised observations were insufficient for the assessment of their conservation status based on IUCN Red List criteria.

Since 1991 to date, an additional 291 species have been discovered in Malaysia, bringing the land snail species total to 970 (Figure 1A). More than 90% of these were new species originally described from Malaysia (49 new species from Peninsular Malaysia and 225 from Sabah and Sarawak) (e.g. Foon *et al.* 2017; Phung *et al.* 2017; Marzuki *et al.* 2021; Vermeulen and Liew, 2022; Liew *et al.* unpublished). This drastic increase in species was a result of several factors, namely, (1) the establishment of specimen collections in the BORNEENSIS collection, Universiti Malaysia Sabah; (2) exploration into more localities of various ecosystems, particularly the isolated ones such as limestone hills, mountaintops, and islands; and (3) continuous taxonomic and faunistic research started by foreign malacologists (Jaap J. Vermeulen and Menno Schilthuizen) and subsequently continued by their locally trained researchers (Figures 1A and 1B). These developments in local land snail research have successfully filled the research and knowledge gaps highlighted by Davison (1991b), such as fragmented and outdated taxonomic research and a lack of systematic surveys to provide data for conservation assessment.

These 970 species of land snails and slugs (hereafter land snails) belong to around 170 genera across 40 families and display a wide variety of colours, shapes, and sizes (Figure 1C) (Liew and Foon 2024). Their size can range from <1 mm to 85 mm, with more than half of the species classified as micro snails (size of < 5 mm). Except for approximately 20 to 30 non-native land snails often found in human settlements, gardens, and plantations, all other species are restricted to natural forests. These forests span the entire elevation gradient, from lowland tropical rainforests up to subalpine forests above 4000 m a.s.l. at Mount Kinabalu (Liew *et al.* 2010). Land snails can also be found in forests across different hydrological and edaphic backgrounds, including heath forest, peat swamp forest, ultramafic forest and limestone forest. Recent studies confirm that the extraordinarily high species diversity and endemism of land snails are overwhelmingly concentrated in highland forests and limestone forests (Liew *et al.* 2014; Vermeulen *et al.* 2015; Foon and Liew, 2017; Khalik *et al.* 2018, 2019).

KEY HABITATS

Highland forest ecosystem

In Peninsular Malaysia, the highland forests above approximately 1000 m a.s.l. harbour land snails with limited distribution, often endemic to these montane habitats (Figure 2A). In contrast, lowland forests are usually occupied by more widespread land snails that can be divided into three distinct assemblages in Peninsular Malaysia: between the east and west sides of the Main Range and adjacent to the Kangar-Pattani line in the northern region, where species affinities are similar to those found in Indochina (Clements *et al.* 2008). In Sabah and Sarawak, particularly Sabah, where the distribution data are more comprehensive, the high-endemism zone begins above approximately 1500 m a.s.l.. Almost all species occurring above 2600 m are endemic to Mount Kinabalu, and lowland land snail assemblages differ between the east and west sides of the Crocker and Trusmadi Ranges. These highland snails are ecologically adapted to the cooler, high-moisture conditions of montane forests (Figure 2B). In Peninsular Malaysia, only 3.8% of the forest lies above 1000 m, with a few peaks exceeding 2000 m, while in Sabah and Sarawak, approximately 6.9% of the combined forest area is above 1000 m, and almost all of the 0.07% of the forest above 2000 m is concentrated in Sabah.

Although no systematic conservation status assessment has been conducted for all highland land snails, many of these highland endemic species are currently under threat. For example, the largest native land snail in Peninsular Malaysia, *Platymma tweediei* Tomlin, 1938, faces risks from increasing habitat degradation and wildlife trade (Figure 2B) (Foon 2014). This species and the other highland endemics are suffering habitat degradation due to logging, agricultural, road and urban development, which is reducing the once continuous forest along the mountain ranges into fragmented and isolated forest islands on the mountain tops (Peh *et al.* 2011). These high-altitude habitats are intrinsically more sensitive to climate change, where the effect of rising temperature is typically more pronounced at higher elevations (Anthony *et al*. 2025). Furthermore, ongoing global warming is causing the upslope shifts of montane cloud forests towards the mountain tops, constricting the available habitat for the land snails adapted to these cool, high-moisture conditions. The subalpine land snails on Mount Kinabalu (above 2600 m) are particularly vulnerable; they are almost entirely endemic to the mountain, likely representing relict lineages that have persisted in these high-elevation refugia through past climate cycles (Liew *et al*. 2020).

Limestone ecosystems

Similar to highland forests, limestone forests, which are almost all lowland forests, harbour remarkably high land snail population density, species richness and endemism compared to the non-limestone lowland forest (Schilthuizen *et al*. 2003; Liew *et al*. 2008). This remarkable density is largely due to the high availability of calcium carbonate (resulting in low acidic soil) in limestone environments, an essential resource for shell growth. These limestone forests on the fragmented and isolated outcrops, known for their distinctive geomorphological features called “fenglin”, function as “islands” (Waltham 2008) (Figures 2A and 2C). The surrounding non-calcareous, highly acidic soils act as barriers to dispersal for many small, slow-moving land snails (Figure 2A). Hence, close to 30% of all known land snail species in Malaysia can only be found on limestone hills. Over tens of millions of years of allopatric speciation, many genera such as *Plectostoma*, *Opisthostoma*, *Georissa*, *Arinia*, and *Diplommatina*, have become exceptionally diverse and hyper-endemic on these limestone hills, with many species restricted to a single hill (Vermeulen 1991, 1993, 1994, 1996; Liew *et al*. 2014; Khalik *et al*. 2018, 2019).

An increasing number of these hills are being developed into tourism sites for their scenic and aesthetic values. However, approximately 10% of limestone hills in Malaysia are currently being quarried or have been completely quarried away (Liew *et al.* 2021) (Figure 3).

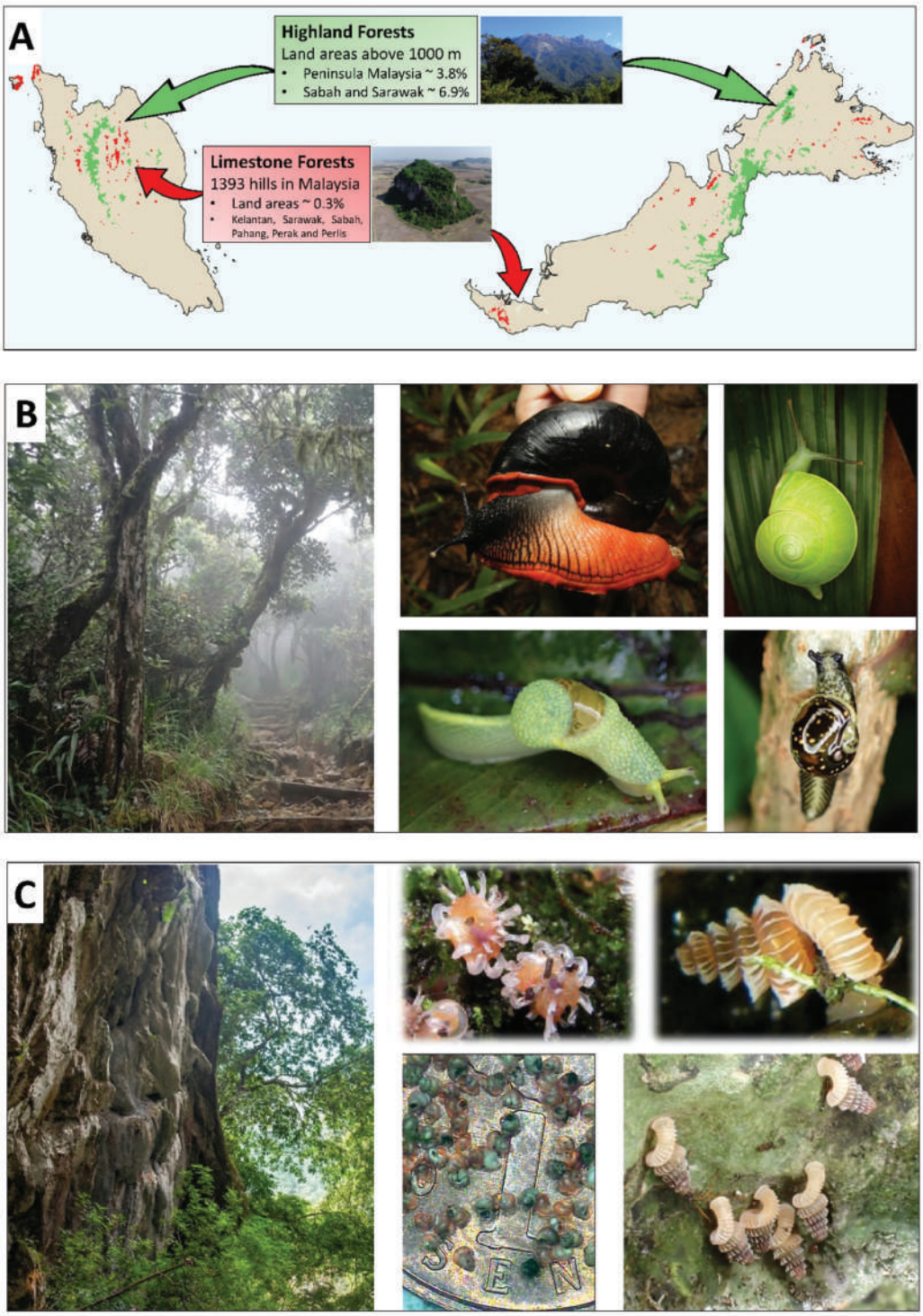

Figure 2. Critical habitats for Malaysia's endemic land snails. **(A)** Distribution map of highland (> 1000 m a.s.l.) forests (green) and limestone forests (red). Highland forests cover only 3.8% of Peninsular Malaysia and 6.9% of Sabah and Sarawak, while limestone hills cover a mere 0.3% of the total land area; **(B)** Highland forest environment and its unique land snails: (top centre) the large, colourful *Platymma tweediei*; (clockwise) *Rhinocochlis chlorosoma*, *Sabalimax pantherina*, and *Ibycus rachelae*; **(C)** Limestone karst ecosystems, which serve as biological islands for rock-dwelling micro snails: (top centre) *Plectostoma grandispinosum*; (clockwise) *Plectostoma siphonostoma*, and *Georissa bangueyensis* (shown against a 1-cent coin for scale).

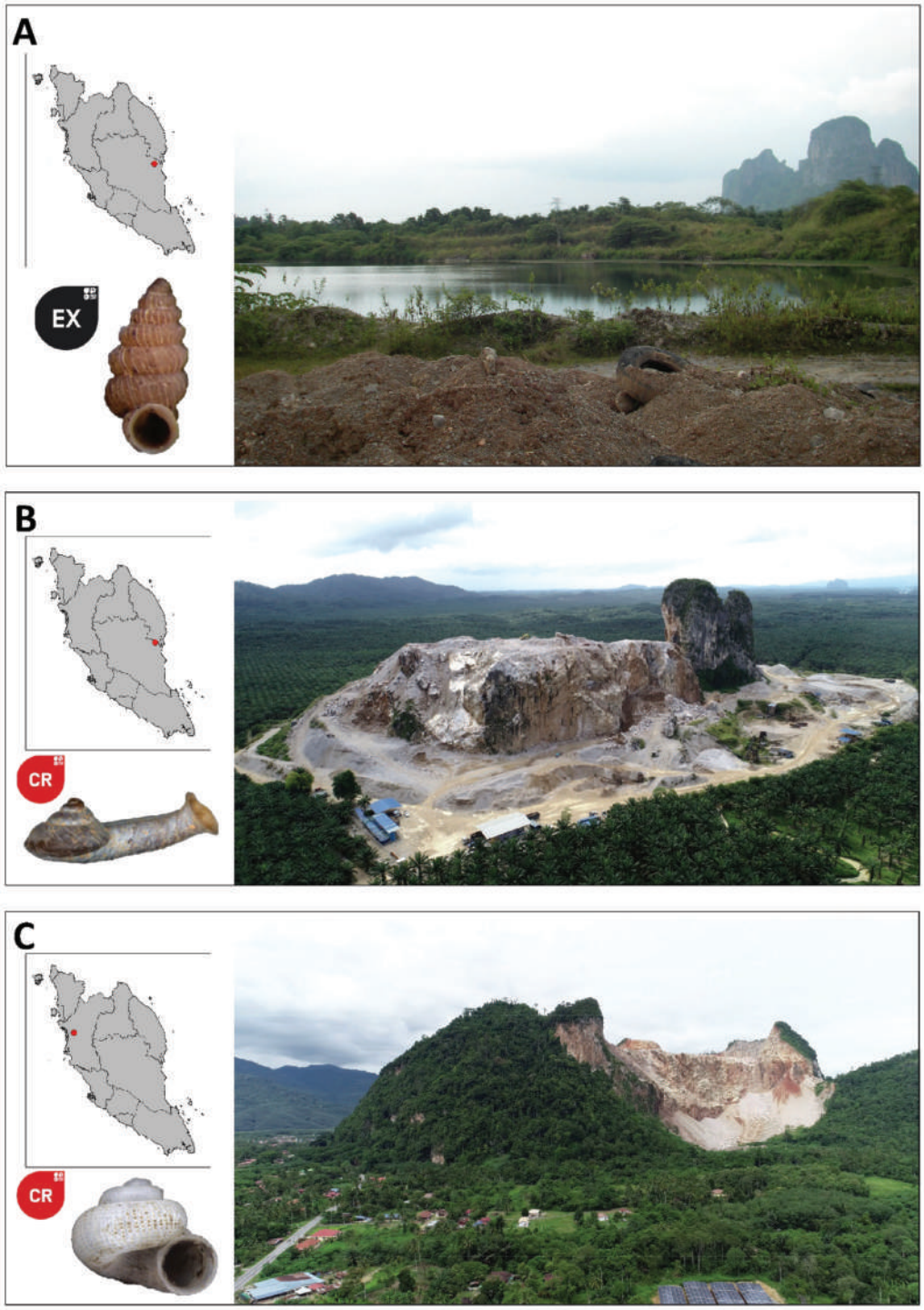

Figure 3. Endangered land snail species endemic to limestone hills in Malaysia (habitat images captured 2018 – 2019). **(A)** The site of Bukit Panching (Phg 72), Kuantan in Pahang, where complete quarrying led to the global extinction (EX) of *Plectostoma sciaphilum*; the photograph shows the abandoned pond remaining after the limestone substrate removal; **(B)** *Hypselostoma elephas* of Bukit Tenggek (Phg 75), Kuantan in Pahang (red dot), is listed as Critically Endangered (CR) due to limestone extraction that has destroyed nearly its entire habitat; the species is projected to go extinct soon; **(C)** *Dicharax microconus* of Gunung Pondok (Prk 55), Perak (red dot), is listed as Critically Endangered (CR) because a large section of the hill has been quarried, highlighting the urgent need for in-situ or ex-situ conservation interventions.

Beyond being a main raw material for the construction sector, lime is also required for the metals industry, environmental protection, agriculture, and the chemical industry (Conway 2003). The extraction of limestone results in irreplaceable habitat destruction. This threat is far more critical than timber extraction from other forest types because the removal of the underlying substrate—the limestone—extirpates the entire ecosystem. Since many endemic plants and animals have evolved specific adaptations to these hills over tens of millions of years, it is unlikely the forest can be restored without the underlying limestone. Therefore, the destruction leads directly to the extinction of endemic plants and animals that have evolved uniquely on those hills.

Limestone hills in a few locations were mentioned in the Nature Conservation in Western Malaysia, 1961 report, such as Kuala Lumpur (Hilton 1961; McClure 1961), Ipoh (Allen 1961) and National Park, Pahang (Hislop 1961). The uniqueness and importance of limestone ecosystems have received increasing attention in the subsequent SoNC 1991 report, where various chapters outlined the threats to limestone flora (Bidin 1991; Kiew 1991a,1991b; Kiew and Pearce 1991; Lamb 1991) and land snails (Davison 1991). However, the importance of these ecosystems extends beyond these groups. Besides land snails, limestone forests are also the sole habitats for many endemic species of herpetofauna (Quah *et al.* 2021) and cave arthropods (e.g. Deharveng *et al.* 2018; Schwendinger 2017; Schwendinger *et al.* 2019; Promdam *et al.* 2022). The conservation challenges facing flora in the limestone ecosystem are presented in another chapter in this SoNC 2025, *Limestone flora of Malaysia: Their threats and conservation* (Rafidah *et al*. 2026).

LAND SNAILS ARE MALAYSIA'S MOST THREATENED TERRESTRIAL ANIMALS

The availability of distribution data for land snails have facilitated the first ever conservation status assessment in 2004. Since then, a total of 40 Malaysian land snails have been placed in the threatened categories (IUCN 2025), comprising 28 Critically Endangered, six Endangered, and six Vulnerable species (Table 1). The 28 critically endangered land snail species are nearly equal to the combined total (29) of critically endangered bird, reptile and mammal species in Malaysia. In 2015, the extinction of two species was officially declared by the IUCN, one of which was the Malaysian land snail species, *Plectostoma sciaphilum*, endemic to the single limestone hill of Bukit Panching, in Pahang (Liew 2015). This extinction represents the only Malaysian terrestrial animal species that is Globally Extinct (Figure 3A). The fact that land snails account for the nation's only Globally Extinct terrestrial species, and hold a staggering 28 Critically Endangered species, demonstrates that they are the most severely threatened terrestrial animal group in Malaysia.

All 40 Malaysian land snail species listed in the IUCN Red List Threatened categories are endemic to limestone hills that are currently facing forest loss and quarrying (Table 1). This vulnerability is directly linked to their high degree of endemism, with many species being restricted to a single limestone hill and sensitive to habitat degradation (Schilthuizen *et al.* 2005; Clements *et al.* 2006). The fate of these limestone hills is clearly illustrated by Bukit Panching, the only known habitat for the extinct land snail *P. sciaphilum* (van Benthem Jutting 1952). The hill has been completely quarried away, leaving behind an abandoned pond where the recovery of the forest and land snail is impossible (Figure 3A). The species was first collected in 1947 and described as a new species in 1952, but was listed as Critically Endangered in 2009 and confirmed extinct in 2015 (van Benthem Jutting 1952; Clements 2009; Liew 2015). This tragic loss was featured in the book, *Lost Wonders: 10 Tales of Extinction from the 21st Century* (Lathan 2024). Another land snail, *Plectostoma tenggekense* (Liew *et al.* 2014), described only in 2014 based on specimens collected in 1997, was immediately listed as Critically Endangered (Liew and Seddon, 2020) and is likely

facing imminent extinction, together with other land snail species, such as *Hypselostoma elephas*, due to ongoing quarrying (Figure 3B). This situation is similar to other Critically Endangered land snails, which face the same threats. Furthermore, many undescribed species may have already become extinct without our knowledge.

Table 1. The conservation status of 55 land snail species in Malaysia is listed in the IUCN Red List (IUCN 2025). The species are categorised by their current IUCN status and taxonomic family.

Conservation Status	No.	Species
EXTINCT	1.	**Diplommatinidae**
		Plectostoma sciaphilum
CRITICALLY ENDANGERED	2.	**Alycaeidae**
	3.	*Chamalycaeus microconus*
	4.	*Chamalycaeus mixtus*
		Stomacosmethis balingensis
	5.	**Charopidae**
		Gleniskos lafargei
	6.	**Diplommatinidae**
	7.	*Arinia boreoborneensis*
	8.	*Arinia dentifera*
	9.	*Arinia oviformis*
	10.	*Arinia simplex*
	11.	*Diplommatina cacuminulus*
	12.	*Diplommatina madaiensis*
	13.	*Opisthostoma thersites*
	14.	*Opisthostoma trapezium*
	15.	*Plectostoma decrespignyi*
	16.	*Plectostoma fraternum*
	17.	*Plectostoma inornatum*
	18.	*Plectostoma jucundum*
	19.	*Plectostoma mirabile*
	20.	*Plectostoma otostoma*
	21.	*Plectostoma perspectivum*
	22.	*Plectostoma charasense*
	23.	*Plectostoma dindingense*
	24.	*Plectostoma retrovertens*
	25.	*Plectostoma tenggekense*
	26.	*Plectostoma turriforme*
		Plectostoma umbilicatum
	27.	**Hypselostomatidae**
	28.	*Hypselostoma elephas*
		Hypselostoma serpa
	29.	**Pupillidae**
		Hypselostoma luctans
ENDANGERED	30.	**Diplommatinidae**
	31.	*Arinia biplicata*
	32.	*Arinia streptaxiformis*
	33.	*Plectostoma dormani*
	34.	*Plectostoma kubuense*
	35.	*Plectostoma palinhelix*
		Plectostoma simplex

VULNERABLE		**Diplommatinidae**
	36.	*Opisthostoma michaelis*
	37.	*Plectostoma bihamulatum*
	38.	*Plectostoma laidlawi*
	39.	*Plectostoma senex*
		Hypselostomatidae
	40.	*Hypselostoma megaphonum*
	41.	*Hypselostoma perigyra*
NEAR THREAENED		**Diplommatinidae**
	42.	*Plectostoma christae*
	43.	*Plectostoma kakiense*
	44.	*Plectostoma mengaburense*
	45.	*Plectostoma tohchinyawi*
LEAST CONCERN		**Diplommatinidae**
	46.	*Plectostoma crassipupa*
	47.	*Plectostoma davisoni*
	48.	*Plectostoma ikanense*
	49.	*Plectostoma kayiani*
	50.	*Plectostoma laemodes*
	51.	*Plectostoma praeco*
	52.	*Plectostoma relauense*
	53.	*Plectostoma salpidomon*
	54.	*Plectostoma siphonostomum*
	55.	*Plectostoma whitteni*

ONGOING ACTIONS AND FUTURE DIRECTIONS FOR LAND SNAIL CONSERVATION

The conservation story of Malaysia's land snails is both compelling and urgent, making them a vital example for many more relatively unknown invertebrates in Malaysia that are now facing extinction. In fact, the urgency of the situation was recognised in the first report, where Allen (1961) stated that conservation action for the limestone ecosystem "*must be done NOW*" and that "*There is still time, but only just time, to prevent this [extinction] occurring to the unique flora and fauna of the limestone hills of Ipoh.*" In the same report, Corner (1961) further noted that proposals had been put to UNESCO to undertake a scientific survey of the limestone hills of Southeast Asia. In the SoNC 1991 report, Kiew (1991) reported that there were no specific statutory and legally restrictive regulations for limestone hills, except for those hills in Taman Negara in Pahang, Gunung Mulu and Niah in Sarawak, as National Parks, and a few hills in recreational forests or forest reserves in Malaysia. She also stressed that at least 200 m of forest around limestone hills needed to be included to maintain the ecological integrity of the hills by providing a buffer zone that prevents direct anthropogenic disturbance immediately adjacent to limestone habitat.

Despite these warnings, legal protection remains limited. Between 2017 and 2025, more limestone hills were included in the National Geoparks of Kinta Valley, Lenggong, Lipis, Langkawi, Labuan, Kenyir, Sarawak Delta, Stong, Gombak-Hulu Langat and Perlis, though these Geoparks do not have the same protection levels as National or State Parks. Furthermore, Niah, Gunung Mulu, Lenggong and Langkawi are later recognised as UNESCO World Heritage and /or Global Geopark sites. Given that existing statutory

protection is inadequate, a proactive and multifaceted approach is required. Therefore, current conservation efforts focus on systematic data generation, legal and ecosystem status assessments, and immediate species survival measures.

Responding to this historical and ongoing crisis, one of the primary conservation efforts is currently focused on generating systematic data on species and their ecosystems to enable the future implementation of high-level policy changes to secure the future of these threatened ecosystems. Crucially, for limestone hills, only around 20% of the hills currently have at least one published biodiversity record, leaving the vast majority of these unique ecosystems scientifically unassessed (Liew *et al.* 2021). This aims not only to identify conservation important species but also to determine which limestone hills are more unique than others, aiding decision-making in conservation prioritisation. This is critical because balancing conservation must account for the extraction of limestone for development; limestone is the second most extracted resource by humans after water, and currently has no substitute, unlike fossil fuels (Conway 2023).

To transform these data into actionable policy, the Forest Research Institute Malaysia (FRIM) has identified limestone and highland ecosystems as key targets for conservation status assessment using the IUCN Red List of Ecosystems framework (Hamidah *et al.* 2024). The establishment of this conservation framework is crucial, as it will enable conservationists, policymakers, industries, and communities to collaboratively plan the future of Malaysia's limestone ecosystems (Liew *et al.* 2021, 2023). Furthermore, this framework serves as a guide for vital future actions, specifically: (i) periodic monitoring of limestone hills, such as the full assessment conducted in 2018 – 2019 (Liew *et al.* 2021), to be repeated every five to ten years; and (ii) conservation status assessment of endemic species, particularly those in highland ecosystems, alongside updating the status of currently IUCN-listed land snail species.

In addition to these data collection and policy initiatives, if avenues for conserving a species' habitat are impractical, immediate action is needed to prevent species extinction, such as emergency collecting for ex-situ conservation and translocation, particularly for the land snail species that are already listed as Critically Endangered (Vermeulen and Whitten 1999; Liew *et al*. 2021) (Figure 3A). Recent in-situ conservation work has also commenced, including the trial of translocation of land snail populations from severely degraded sites to nearby, more protected sites, which has demonstrated promising results (Liew *et al.* 2023).

CONCLUSION

The conservation narrative of land snails presented here serves as a critical case study for the broader invertebrate fauna, which remains largely overlooked. While land snails currently stand as the most threatened terrestrial animal group in Malaysia, this status is likely shared by many other hyper-diverse invertebrate groups that lack comparable taxonomic attention. The trajectory of land snail conservation issues has evolved from initial observations in Nature Conservation in Western Malaysia, 1961 to the arising concerns in SoNC 1991, and finally the critical urgency presented here in SoNC 2025. This development towards urgency is supported by decades of taxonomic research and documentation. To uncover the true state of Malaysia's biodiversity and ensure this diversity does not face silent extinction before discovery, we must acknowledge that many lesser-known invertebrates require equal, if not greater, attention and investment than charismatic vertebrates to develop the taxonomic capacity and conservation actions needed to describe and protect this hidden biodiversity.

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