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# Sambar Deer: A Review on Status, Distribution, Conservation, and Commercial Potential in Peninsular Malaysia

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## ABSTRACT

Sambar deer (*Rusa unicolour*) are native to most parts of Asia, including Malaysia, Taiwan, Indonesia, and India. Listed as "vulnerable" by the International Union for Conservation of Nature's Red List, the animal has recently been introduced into the United States, Australia, and New Zealand. Although they can easily adapt to a wide range of habitats, the population of Sambar deer in the wild has dramatically declined, and this may be attributed to poaching, illegal wildlife trade and habitat loss when jungles are cleared for development. This article provides the status and distribution of Sambar deer in Peninsular Malaysia and protection efforts to conserve this species in the country. It also highlights the potential of Sambar deer commercial farming in Peninsular Malaysia as part of the conservation programme and meeting human demand.

*Keywords*: *Conservation, genomics, Peninsular Malaysia, population,* Sambar deer, wildlife

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## INTRODUCTION

The geographical landscape of Peninsular Malaysia provides a suitable habitat

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reservoir for numerous types of flora and fauna, and the diversity is ranked among the highest in the world (Rintelen et al., 2017). The country's commitment to biodiversity conservation was demonstrated by the ratification of the Convention on Biological Diversity (CBD) in 1994 and the adoption of this concept in its development planning (Ministry of Natural Resources and Environment [NRES], 2006). However, maintaining and managing this huge biodiversity requires proper preservation and sustainable resource use. The dilemma occurred when the development and over-exploitation of resources for human needs impacted the survival of our flora and fauna. Development has reduced potential habitats for wildlife, which can be either for infrastructure, transportation, industry, new settlements, or agricultural purposes. Furthermore, exploitation of resources, either legally or illegally, like poaching, has drastically impacted the survival of protected animal species. For example, the Sumatran rhinoceros is now extinct in Malaysia, and the last rhino died in the captive facility in Sabah in 2019 (Edinur et al., 2022). While poor reproductive fitness and diseases can be linked to the extinction of the Sumatera rhino, as might also be expected for the Malayan tiger (Goossens et al., 2013; Nur-Farahiyah et al., 2021), the proximal risk factors for the extinction of Sumatera rhino might have arisen a few decades ago. These include deforestation and illegal poaching for their parts (i.e., horns; refer to Flynn and Abdullah (1984) for details).

One of the endangered animal species in Peninsular Malaysia is Sambar deer. They are essential in the ecosystem as prey for top predators like Malayan tigers (Kawanishi & Sunquist, 2004). They have high adaptability to diverse habitats and have proven success in captive breeding programs (Moriarty, 2004; Timmins et al., 2015). However, the population size of Sambar deer in Peninsular Malaysia shows a decreasing trend, and they are listed as vulnerable on the list of threatened species (International Union for Conservation of Nature, 2024). In this region, traditional hunting practices and consumption of wild deer venison have been culturally significant among indigenous communities (Bartholomew et al., 2021). Poaching of Sambar deer is also driven by the high value of their meat, which is considered a delicacy by Malaysians and for traditional medicine markets (Dai et al., 2011; Kawanishi et al., 2014). The following sections describe the status, distribution, conservation efforts, and commercial potential of Sambar deer, a native wildlife species in Peninsular Malaysia.

## SAMBAR DEER: DISTRIBUTIONS, THREATS, LEGISLATION AND CONSERVATION EFFORTS

Sambar deer (*Rusa unicolour*) is one of the deer species native to Asia. They are classified into eight sub-species (i.e., *R. u. boninensis*, *R. u. swinhoei*, *R. u. unicolour*, *R. u. brookei*, *R. u. equina*, *R. u. cambojensis*, *R. u. dejeani*, and *R. u. hainan*), and their populations are region-specific. For example, *R. u. unicolour*, *R. u. cambojensis*, and *R. u. dejeani* are widely distributed in South Asia, Southeast Asia, and China, respectively (Ali et al., 2021).

In Peninsular Malaysia, Sambar deer are primarily distributed in the southern and northern parts of Peninsular Malaysia, particularly in protected areas such as Taman Negara, Endau-Rompin, and Belum-Temenggor Forest Complex; refer to Figure 1 and Ali et al. (2021) for range map of other deer species in Peninsular Malaysia. Sambar deer have also been widely introduced to various parts of the world, including Australia and New Zealand (Stafford, 1997; Watter et al., 2020). The animals are highly adaptive and can live from dipterocarp forests to steeper parts of forested hillsides, but they rarely roam far from water sources (Ali et al., 2021; Timmins et al., 2015).

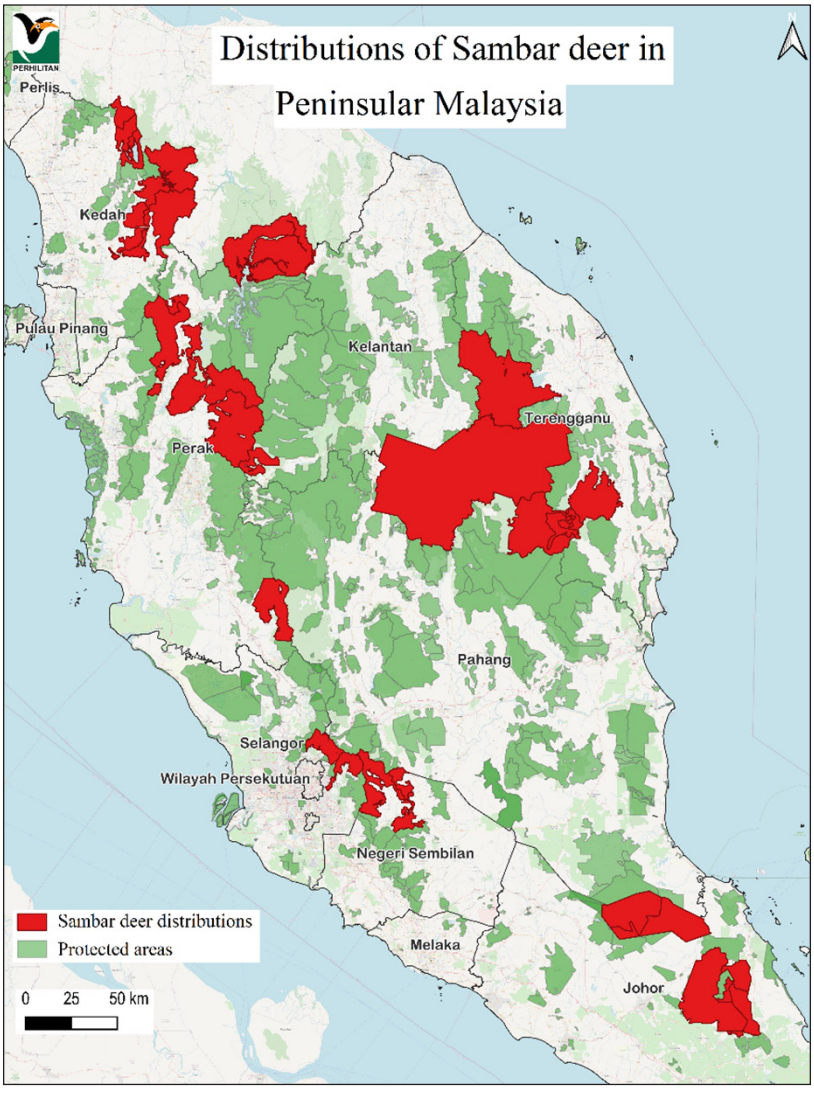


*Figure 1*. Sambar deer distributions in Peninsular Malaysia were mapped during the first National Tiger Survey (Department of Wildlife and National Parks, 2010)

In Peninsular Malaysia, habitats of the Sambar deer have dramatically shrunk from nearly 70,000 sq km in the 1980s to around 50,000 sq km in 2014 (Department of Wildlife and National Parks, 2017). Their population density ranges from around 0.10 to 0.20 individuals per square km (Ali et al., 2021). Even though deer are a natural prey for Malayan tigers, the real threats to their existence are poaching, unsustainable hunting and habitat destruction (Kawanishi et al., 2014). There is increasing demand for meat and antlers of Sambar deer in Southeast Asia, including in Peninsular Malaysia (Leslie Jr, 2011). Bioactive compounds in antlers have anti-infective agents and have been used to treat immune diseases (Dai et al., 2011). Thus, it is unsurprising that antlers are widely adopted in traditional Chinese and Korean medicine (Ali et al., 2021).

Peninsular Malaysia had become one of the hotspots for illegal wildlife trading within the Southeast Asia area, playing the role of a resource supply and transit country (United Nations Office on Drugs and Crime, 2024). Accordingly, a stricter law, the Wildlife Conservation Act 2010 (Act 716) (WCA, 2010), was later enforced in 2010 and replaced earlier laws, including the Wild Animals and Birds Protection Ordinance 1955 and the National Parks Act (PWA) 1972. However, Xin et al. (2022) reported that wildlife crime cases in Peninsular Malaysia showed an increasing and fluctuation pattern from 2012 to 2018, and cases involving Sambar deer were among the most frequently investigated by the Wildlife Forensic Unit, Department of Wildlife and National Parks, Peninsular Malaysia (Department of Wildlife and National Parks, 2018). Fortunately, Sambar deer were rarely involved in human-animal conflicts and as victims in roadkill, which may further reduce their population size. For example, anger and frustration among the farmers and community might result in revenge killing of wildlife, as reported for *Panthera onca* in Venezuela (Jedrzejewski et al., 2017).

In Peninsular Malaysia, Sambar deer are rarely involved in conflicts with humans and are less vulnerable to roadkill as compared with other wildlife species, such as *Macaca fascicularis*, *Sus scrofa*, and *Elephas maximus*; refer to Table S1 and Xin et al. (2024) for roadkill and human-wildlife conflict data in Peninsular Malaysia, respectively. A similar observation was reported elsewhere, including in India, Australia, and Thailand, where Sambar deer are less affected by vehicle collisions (Davies et al., 2019; Habib et al., 2020; Kummoo et al., 2020). There have been fewer than ten recorded road kills involving Sambar deer over the past five years, mainly occurring in forested areas intersecting with highways. As described earlier, the population size of Sambar deer in Peninsular Malaysia is small and is limited to highly protected forest reserves. These might explain the lower conflict and roadkill cases involving Sambar deer in Peninsular Malaysia. Nonetheless, the Malaysian Government spent billions to reduce animal roadkill, including constructing viaducts and bridges at roadkill hotspots (Ten et al., 2021a).

Table S1
*Roadkill data for various species in Peninsular Malaysia from 2017 to 2021*

| Species | Local name | Number | Frequency |
|---|---|---|---|
| *Varanus* spp. | Biawak | 555 | 0.2658 |
| *Macaca fascicularis* | Kera | 400 | 0.1916 |
| *Paradoxurus hermaphroditus* | Musang | 303 | 0.1451 |
| *Sus scrofa* | Babi hutan | 297 | 0.1422 |
| *Felis* spp. | Kucing | 116 | 0.0556 |
| *Python reticulatus* | Ular sawa | 111 | 0.0532 |
| *Tapirus indicus* | Tapir | 94 | 0.0450 |
| *Presbytis* spp. | Lotong | 35 | 0.0168 |
| *Naja kaouthia* | Ular tedung senduk | 16 | 0.0077 |
| *Lutra* spp. | Memerang | 16 | 0.0077 |
| Other bird species | Lain-lain burung | 14 | 0.0067 |
| Other snake species | Lain-lain ular | 14 | 0.0067 |
| *Callosciurus* spp. | Tupai | 13 | 0.0062 |
| *Arctictis binturong* | Binturong | 13 | 0.0062 |
| *Rattus* spp. | Tikus | 9 | 0.0043 |
| *Strigiformes* spp. | Burung hantu | 8 | 0.0038 |
| *Amaurornis phoenicurus* | Burung ruak-ruak | 8 | 0.0038 |
| *Helarctos malayanus* | Beruang | 8 | 0.0038 |
| *Gallus gallus* | Ayam hutan | 8 | 0.0038 |
| *Elephas maximus* | Gajah | 8 | 0.0038 |
| *Nycticebus coucang* | Kongkang | 7 | 0.0034 |
| *Hystrix brachyura* | Landak | 6 | 0.0029 |
| *Naja naja* | Ular tedung selar | 5 | 0.0024 |
| *Herpestes* spp. | Cherpelai | 4 | 0.0019 |
| *Calloselama rhodostoma* | Ular kapak | 4 | 0.0019 |
| *Panthera pardus* | Harimau kumbang | 4 | 0.0019 |
| *Macaca nemestrina* | Beruk | 3 | 0.0014 |
| *Rusa unicolor* | Rusa sambar | 3 | 0.0014 |
| *Manis javanica* | Tenggiling | 1 | 0.0005 |
| *Martes flavigula* | Mengkira | 1 | 0.0005 |
| *Buceros* spp. | Burung enggang | 1 | 0.0005 |
| *Tragulus kanchil* | Pelanduk | 1 | 0.0005 |
| *Panthera tigris jacksoni* | Harimau dahan | 1 | 0.0005 |
| *Tragulus napu* | Napuh | 1 | 0.0005 |
| TOTAL | | 2,088 | 1.0000 |

Sources: Salman Saaban, personal communication, September 15, 2024. Nomenclature as per Malaysia Biodiversity Information System; https://www.mybis.gov.my.

Conservation of the Sambar deer in Peninsular Malaysia involves either *in-situ* or *ex-situ* efforts, discussed by Abidin et al. (1991) and recently described by Ali et al. (2021). In Peninsular Malaysia, the Department of Wildlife and National Parks (DWNP) are actively running the conservation programmes under the Malaysian Energy and Natural Resources Ministry. *Ex-situ* conservation programmes (e.g., captive breeding and release) are primarily important as the deer population in the wild has not shown an increasing trend over the past 12 years (Kawanishi et al., 2014). Therefore, DWNP has taken the initiative to breed Sambar deer at its wildlife conservation centres in Sungkai, Perak, and Gua Musang, Kelantan (both located in Peninsular Malaysia) before introducing the animals back into their natural habitats (Abidin et al., 1991; Ten et al., 2021b). Sambar deer from these two centres were also used as a source of commercial captive breeding of wildlife species.

In 2021, there are 85 Sambar deer (8 fawns) and 101 (21 fawns) at the wildlife conservation centres in Gua Musang, Kelantan and Sungkai, Perak, respectively (Department of Wildlife and National Parks, 2021). From 2014 to 2020, a total of 86 Sambar deer (44 males and 42 females from these centres were released to the wild (i.e., Sungai Relau, Pahang National Park, Kuala Tahan, Pahang National Park, Amanjaya Forest Reserve, Perak, Tembat Forest Reserve, Terengganu, Terengganu National Park, Terengganu, and Gunong Basor, Jeli, Kelantan). These are protected areas, except for Tembat Forest Reserve and Terengganu. The latter is gazetted as a production forest reserve. The survival rate of the released Sambar Deer monitored using Very High Frequency (VHF)-radiotelemetry collars or Global Positioning System (GPS)-satellite collars is between 57 and 75% for the totally protected areas, as compared with 0% for the Tembat Forest Reserve, Terengganu. As might be expected, most Sambar deer released into Tembat Forest Reserve, Terengganu, were illegally hunted (Munisamy et al., 2022).

The population of Sambar deer has significantly declined due to illegal hunting and localised extinctions in several forested areas. This trend, coupled with habitat loss, has severely impacted the prey availability for tigers, which now number around 150 individuals. In areas where law enforcement is not consistently enforced, the Sambar deer population has vanished, leading to ecological imbalances and threatening the survival of apex predators like the Malayan tiger. According to the National Tiger Survey findings, the number of tigers in Malaysia is rapidly decreasing. This alarming decline correlates with the decreasing populations of their primary prey species, including Sambar deer and wild pigs (*Sus scrofa*). The survey revealed that Sambar deer and wild pigs are now rarely captured on camera traps, indicating a sharp decline in their populations. Local communities in tiger-range areas have reported increasing incidences of tigers preying on livestock, such as chickens, dogs, and cats. These behaviours suggest that tigers are venturing into human settlements in search of food due to the depletion of natural forest prey (Rahmat & Azhar, personal communication, September 15, 2024).

In response to this crisis, discussions arose about the potential reintroduction of Sambar deer into tiger habitats to replenish the prey base for Malayan tigers. The idea was initially met with scepticism, as the primary objective of wildlife conservation efforts, particularly those led by the DWNP, is to ensure the survival of species in their natural habitats. However, it became clear that tigers would continue to venture into villages without sufficient prey, posing a threat to both humans and livestock. The suggestion was made that releasing Sambar deer to boost the prey availability for tigers could help mitigate these human-wildlife conflicts (Rahmat & Azhar, personal communication, September 15, 2024).

One of the primary arguments favouring reintroducing Sambar deer was the necessity of sustaining tiger populations in the wild. Studies have shown that tigers require large territories with an abundant and diverse prey base to thrive (Kawanishi & Sunquist, 2004). The drastic reduction of Sambar deer and wild pigs, exacerbated by illegal hunting and habitat destruction, has forced tigers to seek alternative food sources. The depletion of prey species is widely recognised as one of the leading causes of the decline in tiger populations across their range (Karanth, 2010). Therefore, increasing prey availability by reintroducing Sambar deer is vital in supporting tiger conservation efforts. Opponents of the idea argued that the primary purpose of captive breeding and conservation centres is to preserve species like the Sambar deer and to restore their populations in the wild. Releasing Sambar deer into areas with high poaching risks might lead to their rapid demise, thus defeating the conservation purpose. However, a compelling case was made that reintroducing Sambar deer into protected forest reserves, where the risk of poaching can be mitigated, would serve both conservation and ecological objectives. The phrase “better to die in the wild than in the paddock” resonated with those involved, ultimately leading to an agreement that the reintroduction of Sambar deer to bolster the prey base for Malayan tigers was a necessary and noble endeavour (Rahmat & Azhar, personal communication, September 15, 2024).

Evidence from other tiger conservation efforts supports enhancing prey availability as a key to tiger recovery. In India, for example, efforts to restore prey populations through reintroductions and habitat restoration have increased tiger numbers in several reserves (Jhala et al., 2011). A similar approach could be effective in Malaysia, particularly in areas where Sambar deer and other prey species have been driven to local extinction due to overhunting and habitat fragmentation. Despite the potential benefits of Sambar deer reintroduction, several challenges must be addressed for the initiative to succeed. Strict anti-poaching measures must be in place, and effective law enforcement must be maintained to protect the reintroduced deer and the remaining tiger population. Additionally, long-term monitoring of reintroduced Sambar deer is necessary to assess their survival, reproductive success, and overall impact on the ecosystem (Rahmat & Azhar, personal communication, September 15, 2024).

## PROSPECT OF SAMBAR DEER FARMING IN PENINSULAR MALAYSIA

High demand for wildlife products for consumption or medication will lead to over-exploitation of their sources in the natural habitat. Many endangered animal species are also facing poor reproductive rates and habitat loss. These issues, together with ineffective conservation programs, will lead to extinction. While specific data on Sambar deer venison consumption in Peninsular Malaysia is limited, demand for wild meat and antlers has been increasing and driven by traditional beliefs and culinary preferences (UNODC, 2024). Wild sambar deer was laundered as farmed *Rusa timorensis*, lower premium meat and surveys by a non-governmental organisation (Trade in Wild Species) showed that more than 8% of the inspected restaurants (i.e., 242) selling Sambar deer venison in Peninsular Malaysia (Kawanishi et al., 2014). One possible solution is wildlife farming to produce captive breed products to reduce wild harvesting and fulfil human needs demands (Ali et al., 2021; Kawanishi et al., 2014). This initiative has been a great success, including for Sambar deer. For example, Sambar deer were initially introduced and farmed in Australia, and the escape and release of Sambar deer have now become wild herds in the country (Moriarty, 2004).

In Peninsular Malaysia, commercial captive breeding of wildlife species requires a permit from DWNP, and from 2012 until 2018, only one permit for Sambar deer was issued for this purpose. It is far below captive breeding permits issued for other protected species, e.g., Malayan porcupine and Lesser mousedeer (Department of Wildlife and National Parks, 2013, 2014, 2015, 2016, 2017, 2018). The low number of permits issued for Sambar deer farming between 2012 and 2018 was primarily due to stringent permit regulations and the high costs associated with setting up and maintaining captive breeding facilities. The Wildlife Conservation Act 2010 (Act 716) imposes strict requirements on breeders, including habitat management standards, disease control measures, and ongoing monitoring by DWNP officials (Department of Wildlife and National Parks, 2018). Due to the complexity and financial burden of meeting these regulatory demands, it has deterred many potential breeders. Looking at the prospect of Sambar deer farming in other countries, a similar can also be done in Peninsular Malaysia. As described earlier, founder stocks of Sambar deer for commercial breeding can be readily obtained from the Sungkai Wildlife Conservation Centre and Gua Musang Wildlife Conservation Centre, which DWNP established. However, technical support (e.g., on diet and captive conditions) and continuous monitoring and support from DWNP are needed. They should be given to those setting up captive breeding facilities for Sambar deer. These are needed as DWNP is the only agency with experienced personnel on the Sambar deer breeding programme in Peninsular Malaysia.

## GENETICS FOR WILDLIFE CONSERVATION

Genetic studies show that the major histocompatibility complex (MHC) and killer-cell immunoglobulin-like receptor (KIR) genes are the most polymorphic and dynamic in the human and animal genomes (de Groot et al., 2015; Parham & Moffett, 2013; Parham et al., 2012). It confirms the role of MHC and KIR in determining the ability of an organism to cope with disease outbreaks, growth processes, and reproduction. Many genetic studies and DNA bar-coding for species identification are currently using limited information in animal genomes, such as the *cytochrome oxidase subunit 1* genes (*CO1*) of mitochondrial DNA, variable number of tandem repeats (VNTRs), short tandem repeats (STRs), and single nucleotide polymorphisms (SNPs). It is important to note that evolutionary and adaptive processes within and between animal species can be accurately studied by scanning the entire animal genome, including coding and non-coding regions (Ramsay et al., 2019).

However, molecular biology and genomics advancements have limited application in attempts to understand animal biology and diversity and as an intelligent tool in conservation programs (Blanchong et al., 2016; de Groot et al., 2015). For example, wildlife genomic data obtained using next-generation sequencers may be used to inform the characterisation of conservation units (e.g., genes related to adaptive immunity), hybridisation between animal groups (comparative genomics) and drivers of divergence in wildlife (Supple & Shapiro, 2018). Therefore, genomic approaches to conserve Sambar deer and other protected species, especially in Peninsular Malaysia. Based on historical, anecdotal information (Sivananthan, Mohamad Tajuddin and Azhar, personal communication, September 15, 2024), the Sambar deer founders in the captive program established in late 1985 were likely acquired from Zoo Melaka and Sabah (another subspecies) via Singapore, as well as from Taiping Zoo (Kevin, personal communication, September 15, 2024). It would be worthwhile to conduct a genetic study to determine the presence of hybrids and assess the impact of genetic intermixing with the purebred populations from the Peninsular Malaysia subspecies.

## FUTURE DIRECTIONS AND CONCLUDING REMARKS

Sambar deer are depleting in the wild due to habitat degradation and over-exploitation for food and medicinal purposes. Similar to other endangered animal species in Peninsular Malaysia, like sun bears, where illegal hunting for their bile products has caused a severe population decline (Edinur et al., 2022). The current framework of conservation and protection of Sambar deer, including greater enforcement of law in response to illegal poaching and trade, captive breeding and release, as well as habitat management and enrichment, should be expanded as their density has declined throughout Peninsular Malaysia (Ali et al., 2021). Here, using wildlife genomic data and Sambar deer farming could increase the number of Sambar deer in Peninsular Malaysia. Wildlife farming has been very successful elsewhere, including for musk deer (*Moschus* spp.), lion (*Panthera*

*leo*) and mink (*Neovison vison*); refer to Tensen (2016) for details). However, wildlife farming programmes for several other species (e.g., *Hystrix brachyura*, *Heosemys spinose*, *Manis* spp., and *Civettictis civetta*) have no positive impact on conservation, and this was largely due to high production cost, dependent on the wild population as founder stock and laundering of illegal products into captive breeding systems (Nogueira & Nogueira-Filh, 2011; Tensen, 2016). Therefore, attractive subsidy schemes, a systematic protocol for management and tagging of wildlife farming products and a good supply of founder stock (e.g., as currently set up at Sungkai, Perak and Gua Musang, Kelantan Wildlife Conservation Centres) are needed for Sambar deer farming in Peninsular Malaysia.

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