

THE STATUS ON SINGAPORE ISLAND OF THE EURASIAN WILD PIG *SUS SCROFA* (MAMMALIA: SUIDAE)

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ABSTRACT

The Eurasian wild pig (*Sus scrofa* Linnaeus, 1758) is the most adaptable and widespread pig species in the world and is presently Singapore's largest, native, terrestrial mammal. Formerly thought to be extinct on Singapore Island, small numbers persisted only on offshore islands—Pulau Ubin and Pulau Tekong. We review and summarise recent records from Singapore Island, which suggest that it may have recently re-colonised the island from southern Peninsular Malaysia, as well as from Pulau Ubin and Pulau Tekong and is now locally common. Using density estimates from similar sites in Southeast Asia, we estimate that the forests in the Central Catchment Nature Reserve alone may support as many as 552 individuals. We speculate that the large, existing population of wild pigs may alter forest structure and tree composition by reducing seed recruitment and increasing understorey disturbance to saplings, with potential ecological implications on forest tree families like Dipterocarpaceae.

INTRODUCTION

The adaptable and geographically variable Eurasian or common wild pig, *Sus scrofa* Linnaeus, is the most widespread member of the pig family (Suidae), with possibly more than 16 subspecies distributed across much of Europe, North Africa, mainland Asia, Taiwan, and Japan (Nowak, 1999; Groves, 2007; Francis, 2008). Throughout Southeast Asia, it is often the sole pig species occurring in a wide variety of habitats ranging from mature forests to plantations (Francis, 2008). However in parts of Peninsular Malaysia, it overlaps in range with the rarer bearded pig, *Sus barbatus* (see Kloss, 1922; Medway, 1978; Lucchini et al., 2005; Francis, 2008). The form in Peninsular Malaysia, Singapore and western Indonesia, *Sus scrofa vittatus* (= *Sus scrofa peninsularis*) is distinctively smaller, has a sparser coat and fuller crest of black bristles, and is sometimes considered a separate species (see Moulton, 1922; Diong, 1973; Francis, 2008) although recent literature on the family (e.g., Groves, 2007) do not recognise this.

On Singapore Island, the Eurasian wild pig was formerly thought to be extinct (see Harrison, 1974; Yang et al., 1990; Corlett, 1992) in the absence of confirmed records. This is further corroborated by a long-term biodiversity survey in the Central Catchment Nature Reserve (CCNR), the largest remaining patch of forest on Singapore, which did not find any evidence for the occurrence of the Eurasian wild pig (see Teo & Rajathurai, 1997) despite the presence of extensive suitable habitat. In fact, it was then only known from Singapore on two offshore islands—Pulau Ubin, and Pulau Tekong, where it remains fairly common, in the absence of natural predators (Chua, 2000; Baker & Lim, 2008).

Evidence gathered from recent years, however shows that the Eurasian wild pig now occurs, and is increasingly regular at a number of sites on Singapore Island where it is presently the largest native terrestrial mammal. Wild pigs are highly likely to have re-colonized Singapore Island within the last decade, either directly by individuals dispersing from Peninsular Malaysia which is only separated by the narrow Johore straits (Baker & Lim, 2008) or indirectly via Pulau Ubin and Pulau Tekong. Elsewhere, wild pigs are known to be good swimmers, capable of swimming over 9 km of sea (Wallace, 1895), and have apparently colonised the Krakatau Islands, which is at least 13 km from the nearest landmass where they occur (Rawlinson et al., 1992). Here, we summarise recent sight and breeding records of the wild pig on Singapore Island and discuss possible ecological repercussions on the nature reserves and natural vegetation in Singapore.

A REVIEW OF RECENT RECORDS

A review of recent records of the Eurasian wild pig shows that the species now occurs throughout much of Singapore Island north of the Pan-Island Expressway. We did not find nor were we able to locate any records from forested or other well-wooded sites south of the expressway (e.g., forest patches along Clementi Road, Eng Neo Avenue, and Tyersall Road), implying that major roads and built-up areas pose significant barriers to wild pig dispersal. Although we lack quantitative data that show an annual increase in the frequency of records, there is however, good reason to conclude that wild pigs are more common now than a decade ago when they were only reported from Pulau Ubin and Pulau Tekong. While our records are not exhaustive, they provide firm evidence that the Eurasian wild pig is now widespread and established at multiple localities throughout Singapore Island, showing an apparent stronghold in parts of the CCNR (Nee Soon Swamp Forest and Lower Peirce Reservoir) and western Singapore (Choa Chu Kang, Kranji Reservoir and Western Catchment Area). These areas contain the two largest clusters of records (Fig 6.), with a much smaller cluster in eastern Singapore Island and while there are no direct evidence thus far, major roads and urban areas probably limit genetic exchange between their resident populations.

Sightings of wild pigs in the CCNR appear to be concentrated at the Nee Soon Swamp Forest and Old Upper Thomson Road-Lower Peirce Reservoir area. Much of this area is covered in regenerating to tall secondary forests and abandoned fruit orchards. Signs of wild pigs (e.g., muddy wallows—areas of loose soil made by foraging pigs) can be regularly seen along the pipeline in Nee Soon Swamp Forest (see Fig 1, 2). Sightings of pigs in the CCNR are comparatively rarer, possibly a result of their secretive habits and the earliest date we could trace was 6 Dec.2006 when a group of seven adult pigs were observed foraging at a clearing by YDL (Table 1.). Subsequently, AA observed wild pigs in parts of the Nee Soon Swamp Forest during biodiversity surveys in 2008 and 2010. The highest single count of the species to date is 15 individuals, including young on 20 Feb.2010, as reported from the Lower Peirce Reservoir area (R. Krishnan, in litt., 2010). The frequency of sight records from various observers involving large numbers suggests that secondary forests adjoining the Lower Peirce Reservoir support a relatively large population of wild pigs.

Outside of the Nee Soon Swamp Forest—Old Upper Thomson Road area, there is limited evidence of the Eurasian wild pig elsewhere in the CCNR although we have noted the presence of pig diggings in the Rifle Range Road area. Similarly, pig excavations have also been reported from secondary scrub on the CCNR side of the Bukit Timah Expressway, adjacent to the Upper Peirce Reservoir. While we lack sight records from the southern CCNR, anecdotal accounts do suggest that wild pigs have also been sporadically recorded from wooded areas around the Singapore Island Country Club, adjacent tall secondary forest adjoining the MacRitchie Reservoir area (M. Price, in litt., 2010). More evidence is required to clarify the existence of a resident population of wild pigs in this area.

There are few records of Eurasian wild pigs from northeast and eastern Singapore. However, this is likely an artifact of poor sampling rather than genuine rarity in eastern Singapore, given the occurrence of suitable and still extensive secondary scrub and the geographical proximity to the putative source populations on Pulau Ubin and Pulau Tekong. In fact, one of the earliest records came from East Church Road in the Loyang area, which is just beside dense woodland with a pocket of mangrove forest, across the sea from Pulau Ubin. In addition to a sight record of an adult pig from Seletar East camp, there is anecdotal evidence of its occurrence (e.g., diggings) on Pulau Serangoon, a large reclaimed island as documented during a visit in Aug.2009 by BPYHL.

Our records also suggest that the Eurasian wild pig is widely distributed throughout the Western Catchment Area and adjoining wooded area along Choa Chu Kang Road, Bukit Batok West, and adjacent to Kranji Reservoir. Owing to its inaccessibility as a military live-firing area, much of the Western Catchment Area remains comparatively poorly surveyed and there is thus limited information on the occurrence of Eurasian wild pigs. Again, numerous sight records from the wooded areas within the Nanyang Technological University (NTU) campus (S. K. Y. Lum, pers. comm.), immediately south of the Western Catchment Area—a group of three pigs observed at Sungei Gedong on 20 Dec.2005 and a young pig sighted at Poyan Hill on 5 Aug.2006—indicates that Eurasian wild pigs may in fact be locally common. Further observations of a road-kill piglet along Old Choa Chu Kang Road outside Tengah Airbase in Jul.2006 by YDL and two adults in secondary scrub along the Turut Track area (G. C. Tan, pers. comm.) indicates that the species can persist in large patches of mixed secondary forest-abandoned plantation which is still fairly extensive in western Singapore, as well as west and south of the Kranji Reservoir. Ang (2004) documented a record comprising of one adult and four young pigs in the Sungei Buloh Wetlands Reserve (SBWR) on 17 Sep.2004, possibly constituting the reserve's first record. Given the presence of suitable habitats in and around the SBWR, we presume that wild pigs are locally common there.

DISCUSSION

The surge in records of the Eurasian wild pig throughout Singapore Island in the last five to eight years implies that this species is probably surviving well in secondary forest across many parts of northern, western and central Singapore with considerable evidence of breeding. Whether the existing population continues to be augmented by newer

Table 1. Summary of sight and anecdotal records of the Eurasian wild pig (*Sus scrofa*) on Singapore Island.

Locality	Sighting Date	Number of Individuals	Observer/Source
Lower Peirce Reservoir Park	10 Feb.2010	1	S. C. Fang
Old Upper Thomson Road	8 Feb.2010	Up to 10	Spykerman (2010)
Old Upper Thomson Road	Feb.2010	10–14	J. Heng
Lower Peirce Trail	Feb.2010	1	G. C. Tan
Nee Soon Swamp Forest	20 Jan.2010	2 adults and 1 young	A. Ang
Lower Peirce Reservoir Park	28 Nov.2009	1	R. Lim
Lim Chu Kang Road, Murai	6 May 2009	1	A. Chia
Lower Peirce Trail	20 Feb.2009	Up to 15, including young	R. Krishnan
Neo Tiew Lane 2	2009	2	G. Francis
Yio Chu Kang	2009	1	M. Hall
Old Upper Thomson Road	27 Sep.2008	1	A. Ang, A. & S.D. Fam
Old Upper Thomson Road	24 Sep.2008	4	A. Ang, A. & S.D. Fam
Seletar East Camp	Sep.2008	1	K. H. Tan
Warren Grassland	2 Aug.2008	4	K. H. Tan
Turut Track	May 2008	2	G. C. Tan
NTU (Hall 12/13)	2008	1 adult and 3 young	S. K. Y. Lum
Mowbray Road	6 Oct.2007	1	Anon. (2007)
Bukit Batok Road	2007	1	C. Pui
Poyan Hill	5 Aug.2006	1 young	K. H. Tan, C. Foley & D. Lau
Nee Soon Swamp Forest	6 Dec.2006	7	D. L. Yong
Old Choa Chu Kang Road	Jul.2006	1 young	D. L. Yong & R. Zhao
Sungei Gedong	20 Dec.2005	3	B. Lee
Sungei Buloh WR	17 Sep.2004	1 adult and 4 young	Ang (2004)
Changi Golf Course	11 May 2004	1	Ting & Ng (2004)
East Church Road	2000	1	B. Lee
Anecdotal accounts based on other evidence (e.g., wallows, diggings)			
Jalan Bahar	2010	No information	H. C. Ho & C. Ng
Neo Tiew Lane 2	Apr.2010	No information	H. C. Ho
Pulau Serangoon	Aug.2009	No information	B. Lee
Upper Peirce Reservoir	2009	No information	B. Lee
Neo Tiew Lane 2	2009	No information	H. C. Ho
Rifle Range Road	Oct.2008	No information	D. L. Yong
Bukit Batok West	Undated	No information	J. W. Ho
Island Club Road	Undated	No information	M. Price
Sungei Buloh WR	Undated	No information	H. Flotow
Nee Soon Swamp Forest	Undated	No information	H. Flotow

dispersants from Peninsular Malaysia is difficult to document, but it seems most likely that the individuals in secondary forest, and oil palm plantations in southernmost Johor, Malaysia form the source population of wild pigs currently present in Singapore. It is unclear how the Eurasian wild pig, being such an adaptable species became extinct on Singapore Island, as documented by Yang et al. (1990), and Corlett (1992), although hunting pressure, spurred by undocumented levels of wild meat demand may have contributed to its decline in the past. Illegal hunting of wild pigs on Singapore Island is still fairly rampant (e.g., Anon., 2007; Ting, 2009), but there is no information on how this has impacted local populations.

Yang et al. (1990) speculated that the remnant population present on Pulau Tekong arose from colonists originating from nearby Johor, which is highly plausible considering the shallow Johor straits separating Pulau Tekong from Johor and the extensive source habitat along the Johor coast. Many species of wild pig are good swimmers and can breach considerable stretches of sea (Rawlinson et al., 1992). Similarly, wild pigs could have swum across other parts of the relatively narrow Johor straits and established populations on Pulau Ubin, and parts of the northeast, northern and western coasts (e.g., Changi, Lim Chu Kang, Neo Tiew, Sungei Buloh, Poyan) (see Ang, 2004; Baker & Lim, 2008) which being secondary forest, abandoned fruit orchards, rubber plantations, and mangrove forests, formed suitable habitat. Likewise, pigs could have also reached Singapore Island from Pulau Ubin and Pulau Tekong. Considerable movements of small groups of wild pigs would have then led to eventual colonisation of forested sites away from the



Fig 1. A permanent Eurasian wild pig wallow at Nee Soon Swamp Forest. (Photograph by: Andie Ang).



Fig 2. A 'digging', formed by foraging pigs along the forest edge at Nee Soon Swamp Forest. (Photograph by: Andie Ang).



Fig 3. A group of three sub-adult individuals in the Lim Chu Kang Road area. (Photograph by: Benjamin Lee).



Fig 4. A young individual, showing the characteristic striped-patterning on the body, from Panti Forest Reserve, Johor, Malaysia. (Photograph by: Yong Ding Li).

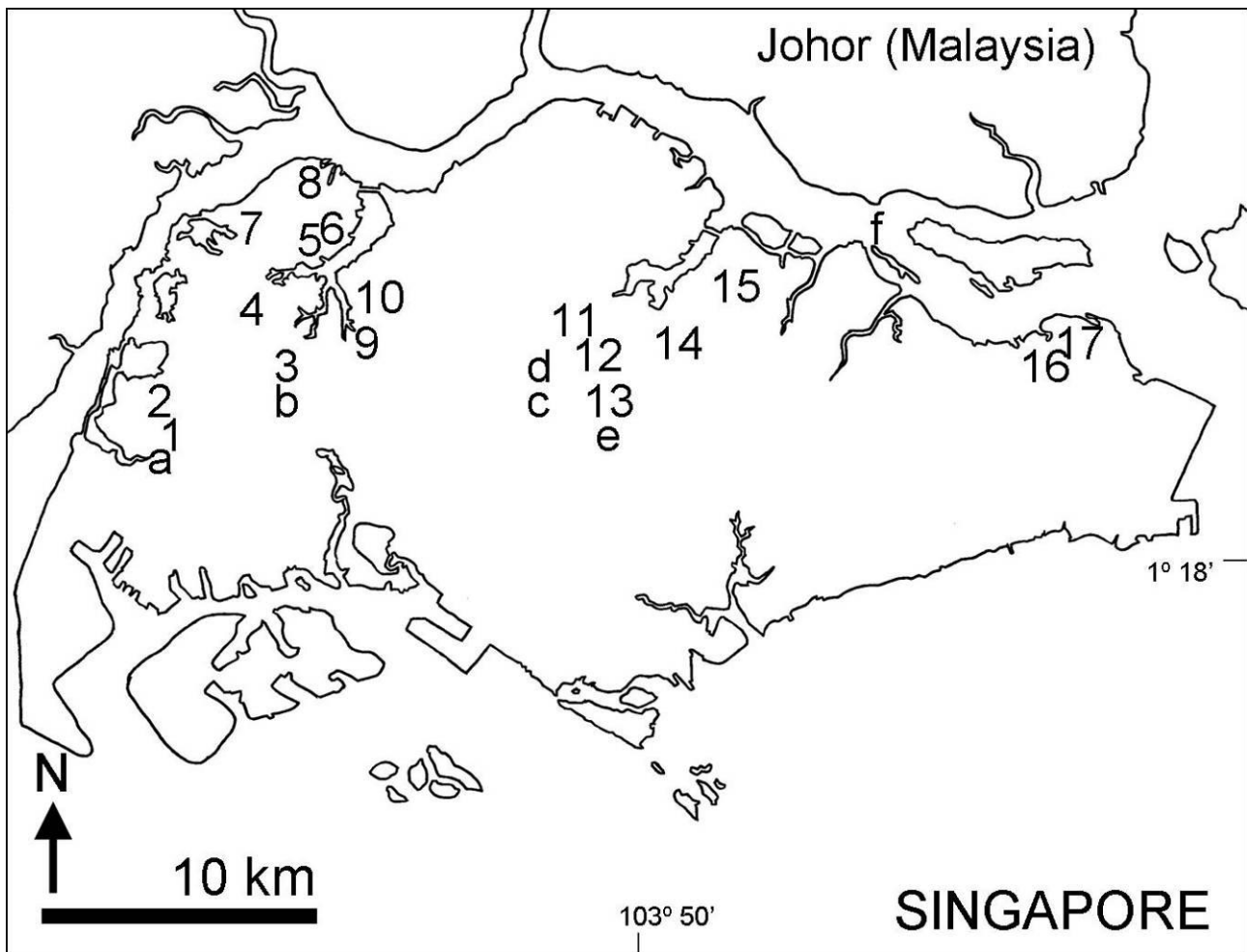


Fig 5. Map of Singapore showing relative locations of the records. Localities with confirmed sight records are marked with numbers: 1 (Nanyang Technological University), 2 (Poyan Hill), 3 (Old Chua Chu Kang Road-Tengah Airbase), 4 (Lim Chu Kang Road), 5 (Neo Tiew Lane 2), 6 (Turut Track), 7 (Sungei Gedong), 8 (Sungei Buloh Wetlands Reserve), 9 (Warren Grassland), 10 (Mowbray Road), 11 (Nee Soon Swamp Forest), 12 (Lower Peirce Trail), 13 (Old Upper Thomson Road), 14 (Yio Chu Kang), 15 (Seletar East Camp), 16 (East Church Road), 17 (Changi Golf Course). Localities with anecdotal information are marked with lower-case alphabets: a (Jalan Bahar), b (Bukit Batok West), c (Rifle Range Road), d (Upper Peirce Reservoir), e (Island Club Road), f (Pulau Serangoon).

coast though this will require individuals or groups of pigs to cross busy roads (see Spykerman, 2010) and might explain why pig observations are presently restricted to localities north of the Pan-Island Expressway.

Currently, a population of unknown size is established in the CCNR, particularly in the Nee Soon Swamp Forest and Upper Thomson Road area. Using the density estimates from the Pasoh Forest Reserve and Peucang Island—both of which contain similar habitats— a density of 23.6-45.4 individuals km^2 is obtained, which implies that the CCNR may potentially support an estimated 552 wild pigs' (Table 2.). We however recommend this estimate be cautiously interpreted as many animals exhibit aggregative behaviour in response to unevenly distributed food resources at local spatiotemporal scales. Our field surveys in the swamp forest in the past eight years have consistently and very frequently documented signs of wild pig, for instance loose soil diggings and mud wallows, suggesting that wild pigs are locally common. There are also many instances where small groups of wild boars were observed foraging along forest clearings at Nee Soon Swamp Forest. Elsewhere in the CCNR, sightings and signs of wild pigs in the Lower Peirce Reservoir, Old Upper Thomson Road and MacRitchie Reservoir forests suggest that populations may be already established. Not surprisingly, there are presently no sites in southern Singapore that have records of wild pigs and a possible explanation is the large number of bisecting major roads, notably the Pan-Island Expressway and built-up areas that separate the central forests from the south, forming a considerable barrier for dispersive movements.

With the extinction of all large mammalian carnivores (e.g., tiger, or leopard) in Singapore by the mid-twentieth century (Corlett, 1992; Baker & Lim, 2008), it is clear that the existing populations of Eurasian wild pigs are no longer subjected to any natural predation pressure except possibly the reticulated python (*Python reticulatus*) which is known to consume wild pigs elsewhere (Auliya, 2003; Fredriksson, 2005). Wherever wild pigs co-occur with large predators,

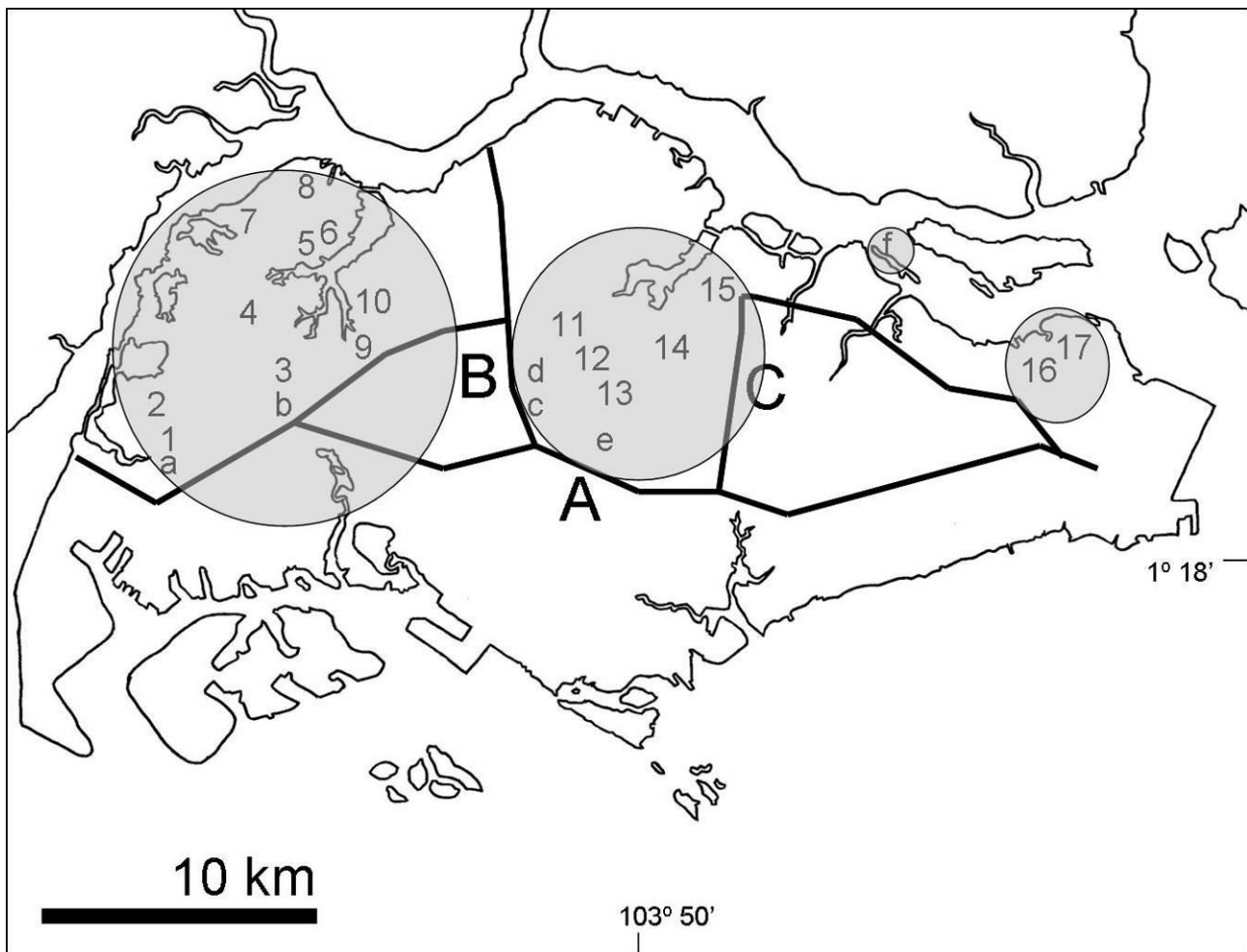


Fig 6. Map of Singapore showing the clusters of Eurasian wild pig records. The largest two clusters are the western cluster [including the Western Catchment, Kranji Reservoir, Sungei Buloh Wetland Reserve (SBWR)] and the central cluster [Central Catchment Nature Reserve (CCNR) and Yio Chu Kang]. Major roads probably prevent individuals from traveling from one cluster to another; potentially limiting genetic exchange between their resident populations. Major roads are marked in capital letters. A = Pan-Island Expressway, B = Bukit Timah Expressway, and C = Central Expressway.

they often form the principal prey items and predators like large cats may play an important role in limiting population densities of pigs (Rabinowitz, 1989; Ickes, 2001a). For example, the tiger (*Panthera tigris*) whose most important potential prey item is the Eurasian wild pig in parts of Peninsular Malaysia (Kawanishi & Sunquist, 2004) was extirpated from Singapore since the 1930s (Tan et al., 2010). In the near-total absence of natural predation pressure, competition from large terrestrial herbivores which are mostly extinct [except for a naturalized population of sambar deer (*Cervus unicolor*)] and high fecundity (Diong, 1973; Bieber & Ruf, 2005), it is likely that the population density of wild pigs on Singapore Island will increase substantially, limited only by habitat and food availability. Indeed, we noted that wild pig densities in Southeast Asian sites lacking large predators exceed that of sites with large predators by nearly 10 times (Table 2., Fig 7.). Unusually high densities of pigs may lead to some plausible impacts on ecological processes like seed dispersal and recruitment in existing forest fragments, especially CCNR primary and tall secondary forests.

Extensive studies in Pasoh Forest Reserve, a forest fragment now largely devoid of major mammalian predators in Peninsular Malaysia showed that the activities of super-abundant wild pigs heavily disturb woody saplings and possibly soil properties through stem snap, and rooting activities during foraging (Ickes, 2001a, b; Ickes et al., 2003). As many as 170 000 saplings per km² per year may be damaged by female wild pigs in constructing nests for reproduction, while canopy species exhibited lower survival rates than understorey species like various shrubs and treelets (Ickes et al., 2003). Overall damage reaches 0.53% mortality per year for all trees with DBH 1–2 cm attributable solely to wild pigs and as much as 29% of observed tree mortality of sapling DBH 1–2 cm (Ickes et al., 2005). Ickes et al. (2001) also documented higher recruitment rates, height growth, and stem densities in fenced plots as compared to unenclosed plots that were exposed to wild pig activity. While the role of wild pigs as seed predators is still not well-understood, they are major post-dispersal seed predators and with their generalized diets contribute directly to seed losses for many tree species, especially dipterocarps (Miura et al., 1997; Corlett, 1998; Sun et al., 2007). A study by Curran et al. (1999) in Borneo showed that intense seed predation by the closely related bearded pig *Sus barbatus* led to a complete lack of

Table 2. Density estimates of wild pigs at various forest sites in Southeast Asia. Wild pig densities at sites with large predators differed from sites with no large predators by almost thirteen times. Using mean population densities from similar habitat types in Indonesia and Peninsular Malaysia, we estimate that the CCNR may potentially support a density of as high as 34.5 individuals per km², giving a combined population of about 552 individuals for the entire CCNR.

Country	Location	Vegetation type	Density (N per km ²)	Source
Sites with large predators				
Indonesia	Bukit Barisan National Park, Sumatra (1998)	Lowland and hill dipterocarp forest	6.06	O'Brien et al., (2003)
Indonesia	Bukit Barisan National Park, Sumatra (1999)	Lowland and hill dipterocarp forest	4.5	O'Brien et al., (2003)
Malaysia	Dindings, Perak	Lowland dipterocarp and coastal forest	< 1.0	Diong (1973)
Malaysia	Merapoh, Taman Negara National Park	Lowland dipterocarp forest	4.17	Kawanishi & Sunquist (2004)
Malaysia	Kuala Trenggan, Taman Negara National Park	Lowland dipterocarp forest	3.63	Kawanishi & Sunquist (2004)
Malaysia	Kuala Koh, Taman Negara National Park	Lowland dipterocarp forest	4.62	Kawanishi & Sunquist (2004)
Thailand	Huai Kha Khaeng wildlife sanctuary	Dry dipterocarp forest	< 0.5	Srikosamatara (1993)
Sites with no large predators				
Indonesia	Peucang island, Ujong Kulon National Park, Java	Coastal dipterocarp forest	27–32	Pauwels (1980)
Malaysia	Pasoh forest reserve (1996)	Lowland dipterocarp forest	47.0	Ickes (2001)
Malaysia	Pasoh forest reserve (1998)	Lowland dipterocarp forest	27.0	Ickes (2001)
Mean density for predator-present sites (n = 7)			3.50 ± 2.02	
Mean density for predator-absent sites (n = 3)			34.5 ± 10.9	
Estimated population for CCNR			552	

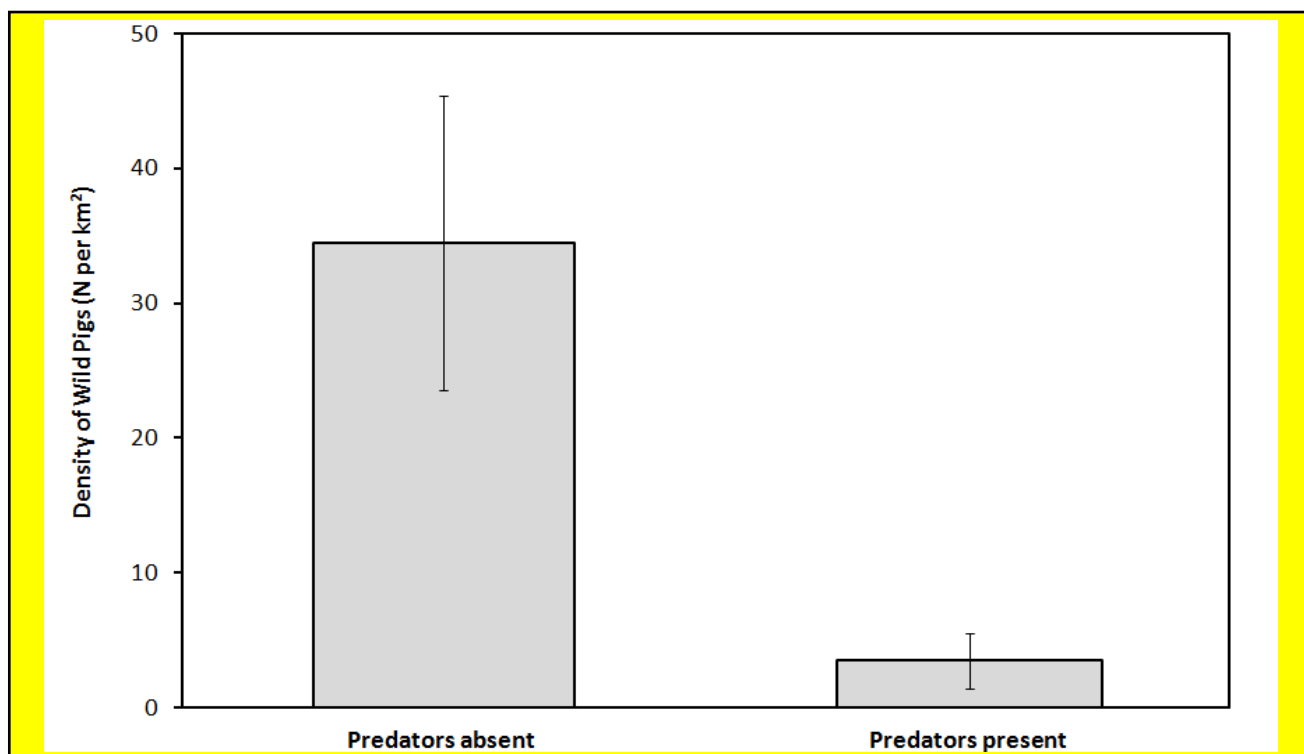


Fig 7. Differences in Eurasian wild pig densities between Southeast Asian sites with large predators and sites with no large predators. Sites lacking large predators (e.g., leopard, or tiger) exhibit a nearly ten-fold inflation of Eurasian wild pig densities.

seed recruitment for dipterocarps over 10 years. Clearly, these examples highlight that wild pigs are able to alter plant communities especially in small forest fragments (Ickes & Thomas, 2003).

Given the similarities in conditions with Pasoh where the bulk of studies on wild pig disturbance were conducted, comparable scenarios could arise in primary and secondary forests in the CCNR, which is a forest fragment of about 1,600 Ha (Corlett, 1992). Assuming a spread of wild pigs to currently unpopulated areas within the CCNR and with similar rates and magnitudes of sapling damage, elevated populations of wild pigs may potentially damage over a million saplings a year, severely impacting successful recruitment of many primary forest tree species. Despite their dominance in lowland forests, Dipterocarps like various *Shorea* species appear to be particularly vulnerable to pig disturbance. Not only are dipterocarp saplings preferentially used for nest-building, seeds are also frequently predated upon (Miura et al., 1997; Ickes, 2001a). Furthermore, the presence of wild pigs may encourage the spread of the invasive Koster's curse (*Clidemia hirta*) throughout the CCNR by increasing successful establishment of the shrub at leaf litter-free sites made by pigs (Teo et al., 2003). In the long term, increased densities of wild pigs may drastically alter tree composition and overall forest structure within the CCNR.

The ecological impacts of wild pigs however are not solely limited to altering forest composition and structure. Lessons drawn from Pasoh and Pulau Ubin showed that microhabitat regime changes driven by pigs may negatively or positively impact local animal communities. In Pasoh, Kemper & Bell (1985) showed that disturbances arising from wild pigs foraging to leaf litter and understorey vegetation reduced food availability to small terrestrial mammals like forest rats (*Rattus* species) and treeshrews (*Tupaia* species), as suggested by reduced numbers of small mammal captures from areas subjected to wild pig disturbance. Furthermore their destructive foraging methods may pose a threat to freshwater crab species, such as the critically endangered endemic *Parathelphusa reticulata* by disturbing small streams in the Nee Soon Swamp Forest and thus reducing habitat availability. On the other hand, the presence of wild pigs may be beneficial to certain species, particularly dung beetles. Dung removal experiments conducted by Lee et al. (2008) on Pulau Ubin, where wild pigs are common, documented comparatively higher levels of dung removal than control sites, indicating that the resident dung beetle community may be healthier compared to various sites studied by Lee et al. (2008) throughout Singapore.

Wild pig populations in Singapore will probably continue to flourish in the absence of natural predation pressures although illegal hunting (e.g., Anon, 2007; Ting 2009) and authorised culling to control populations in places like Tengah Airbase to ensure safety in aircraft maneuvering areas (Agri-Food and Veterinary Authority, pers. comm.) will ironically have the greatest impact on populations. A highly plausible ecological outcome however is that forest composition and structure, particularly in the nature reserves will face increased disturbance from wild pig foraging and breeding behavior, potentially altering conditions for successful recruitment and regeneration of primary forest trees species like dipterocarps, other forest shrubs (including potentially endangered species) and thus impeding forest succession. Secondly, wild pig-assisted dispersal of the seeds of Koster's curse may cause increased penetration of this invasive shrub into more areas of the CCNR, especially the Nee Soon Swamp Forest which is a high priority conservation area owing to its rich freshwater fauna and unique vegetation type (Ng & Lim, 1992).

Given these scenarios, the Eurasian wild pig in Singapore presents a unique conservation dilemma in view of currently heavy prioritization to conserve Singapore's remaining primary and old secondary forests. Management of wild pig populations through culling may be inevitable in the long-term, especially in the nature reserves, and there are established methods such as fencing, cage traps, snares, and shooting (see Campbell & Long, 2009). Highly urbanized Hong Kong, for instance, has embarked on a culling programme to control the pig population in rural and semi-rural areas and to prevent further human-wildlife conflicts (Nagpal, 2009) such as traffic accidents involving wild pigs and attacks on humans. At present, field surveys would be urgently needed to assess the population trends of wild pigs present throughout Singapore Island and their impacts on vegetation, especially primary and mature secondary forest in the CCNR. Furthermore, studies would also need to examine local foraging ecology and diet in greater resolution to determine and ascertain threats posed to native biodiversity.

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LITERATURE CITED

- Ang, J., 2004. Wild boar sightings at Sungei Buloh. *Wetlands*, **10**(3). <http://www.sbwr.org.sg/Wetlands/text/04-103-8.htm>. (Accessed 9 May 2010).
- Anon, 2007. Wild boar trapped by poachers on SAF land dies. *Today Online*, 6 October 2007. http://www.acres.org.sg/news/news_today-06oct 07.html. (Accessed 10 May 2010).

- Auliya, M., 2003. A reticulated python (*Python reticulatus*) preys on an adult Sulawesi wild pig (*Sus celebensis*). *Asian Wild Pig News*, **3**(1): 11–12.
- Baker, N. & K. K. P. Lim, 2008. *Wild Animals of Singapore. A Photographic Guide to Mammals, Reptiles, Amphibians and Freshwater Fishes*. Draco Publishing and Distribution Pte Ltd and Nature Society (Singapore), Singapore. 180 pp.
- Bieber, C. & T. Ruf, 2005. Population dynamics in wild boar *Sus scrofa*: ecology, elasticity of growth rate and implications for the management of pulsed resource consumers. *Journal of Applied Ecology*, **42**(6): 1203–1213.
- Campbell, T. A. & D. B. Long, 2009. Feral swine damage and damage management in forested ecosystems. *Forest Ecology and Management*, **258**(10): 2319–2326.
- Chua, E. K., 2000. *Pulau Ubin: Ours to Treasure*. Simply Green, Singapore, 139 pp.
- Corlett, R. C., 1992. The ecological transformation of Singapore, 1819–1990. *Journal of Biogeography*, **19**(4): 411–420.
- Corlett, R. C., 1998. Frugivory and seed dispersal by vertebrates in the Oriental (Indomalayan) region. *Biological Reviews*, **73**(4): 413–448.
- Curran, L. M., I. Caniago, G. D. Paoli, D. Astianti, M. Kusneti, M. Leighton, C. E. Nirarita & H. Haeruman, 1999. Impact of El Niño and logging on canopy tree recruitment in Borneo. *Science*, **286**(5447): 2184–2188.
- Diong, C. H., 1973. Studies of the Malayan wild pig in Perak and Johore. *Malayan Nature Journal*, **26**(3–4): 120–151.
- Francis, C. M. 2008. *A Field Guide to the Mammals of South-east Asia*. New Holland Publishers, (UK) Ltd, 392 pp.
- Fredriksson, G. M., 2005. Predation on sun bears by reticulated python in east Kalimantan, Indonesian Borneo. *Raffles Bulletin of Zoology*, **53**(1): 165–168.
- Groves, C. P., 2007. Current views on taxonomy and zoogeography of the genus, *Sus*. In: Albarella, U., K. Dobney, A. Ervynck. & P. Rowley-Conwy (eds.), *Pigs and Humans. 10 000 Years of Interaction*. Oxford University Press, UK. Pp 15–29.
- Harrison, J. L., 1974. *An Introduction to Mammals of Singapore and Malaya. 2nd Edition*. Malayan Nature Society, Singapore, 340 pp.
- Ickes, K., 2001a. Hyper-abundance of native wild pigs (*Sus scrofa*) in a lowland dipterocarp rain forest of Peninsular Malaysia. *Biotropica*, **33**(4): 682–690.
- Ickes, K., 2001b. The effects of wild pigs (*Sus scrofa*) on woody understorey vegetation in lowland rain forest of Malaysia. Unpublished PhD dissertation, Louisiana State University, Baton Rouge. 83 pp.
- Ickes, K., S. J. Dewalt & S. Appanah, 2001. Effects of native pigs (*Sus scrofa*) on woody understorey vegetation in a Malaysian lowland rainforest. *Journal of Tropical Ecology*, **17**(2): 191–206.
- Ickes, K. & S. C. Thomas, 2003. Native, wild pigs (*Sus scrofa*) at Pasoh and their impacts on the plant community. In: Okuda, T., Manokaran, N., Matsumoto, Y., Niiyama, K., Thomas, S. C. & P. S. Ashton (eds.), *Pasoh: Ecology of a Lowland Rain Forest in Southeast Asia*. Springer-Verlag, Tokyo. Pp. 507–520.
- Ickes, K., S. J. Dewalt & S. C. Thomas, 2003. Resprouting of woody saplings following stem snap by wild pigs in a Malaysian rain forest. *Journal of Tropical Ecology*, **92**(1): 222–233.
- Ickes, K., C. J. Paciorek & S. C. Thomas, 2005. Impact of nest construction by native pigs (*Sus scrofa*) on lowland Malaysian rain forest saplings. *Ecology*, **86**(6): 1540–1547.
- Kawanishi, K. & M. E. Sunquist, 2004. Conservation status of tigers in a primary rainforest of Peninsular Malaysia. *Biological Conservation*, **120**(3): 329–344.
- Kemper, C. & D. T. Bell, 1985. Small mammal and habitat structure in lowland rain forest of Peninsular Malaysia. *Journal of Tropical Ecology*, **1**(1): 5–22.
- Kloss, C. B., 1931. The bearded pig (*Sus barbatus*) in the Malay states. *Raffles Bulletin of Zoology*, **82**: 102–105.
- Lee, J. S. H., I. Q. W. Lee, S. L-H. Lim, J. Huijbregts & N. S. Sodhi, 2009. Changes in dung beetle communities along a gradient of tropical forest disturbance in South-east Asia. *Journal of Tropical Ecology*, **25**(6): 677–680.
- Lucchini, V., E. Meijaard, C. H. Diong, C. P. Groves, & E. Randi, 2005. New phylogenetic perspectives among species of South-east Asian wild pigs (*Sus* sp.) based on mtDNA sequences and morphometric data. *Journal of Zoology*, **266**(1): 25–35.
- Medway L., 1978. *The Wild Mammals of Malaya (Peninsular Malaysia) and Singapore*. Oxford University Press, Kuala Lumpur. 128 pp.
- Miura, S., M. Yasuda & L. Ratnam, 1997. Who steals the fruits? Monitoring frugivory of mammals in a tropical rainforest. *Malayan Nature Journal*, **50**(2): 183–193.
- Moulton, J. C., 1922. *Mammals of Malaysia. Part 1: Malaysian Ungulates*. Methodist Publishing House, Singapore. 81 pp.
- Nagpal, S., 2009. Control of Hong Kong boar population urged after man savaged. *TopNews*, 4 August 2009. <http://www.topnews.in/control-hong-kong-boar-population-urged-after-man-savaged-2148979>. (Accessed 21 May 2010).
- Ng, P. K. L. & K. K. P. Lim, 1992. The conservation status of the Nee Soon freshwater swamp forest of Singapore. *Aquatic Conservation: Marine and Freshwater Ecosystems*, **2**(3): 255–266.
- Nowak, R.M., 1999. *Walker's Mammals of the World. Volume 1. 6th Edition*. The John Hopkins University Press, Baltimore. 2015 pp.
- O'Brien, T. G., M. F. Kinnaird & H. T. Wibisono, 2003. Crouching tigers, hidden prey: Sumatran tiger and prey populations in a tropical forest landscape. *Animal Conservation*, **6**(2): 131–139.

- Pauwels, W. 1980. Study of *Sus scrofa vittatus*, its ecology and behavior in Ujung Kulon nature reserve, Java, Indonesia. Unpublished PhD dissertation, University of Basel, Switzerland. 100 pp.
- Rabinowitz, A. 1989. The density and behavior of large cats in a dry tropical forest mosaic in Huai Kha Khaeng wildlife sanctuary, Thailand. *Natural History Bulletin of the Siam Society*, **37**(2): 235–251.
- Rawlinson, P. A., R. A. Zann., S., van Balen. & I. W. B. Thornton, 1992. The recolonisation of the Krakatau islands by vertebrates. *GeoJournal*, **28**(2): 225–231.
- Spykerman, K., 2010. Wild boars hog the limelight in Thomson neighbourhood. *The Straits Times*, 7 Feb.2010. <http://www.straitstimes.com/Breaking News/Singapore/Story/STIStory487704.html>. (Accessed 10 May 2010).
- Srikosamatara, S. 1993. Density and biomass of large herbivores and other mammals in a dry tropical forest, western Thailand. *Journal of Tropical Ecology*, **9**(1): 33–43.
- Sun, I-F., Y-Y. Chen., S. P. Hubbell, S. J. Wright & N. S. Noor, 2007. Seed predation during general flowering events of varying magnitude in a Malaysian rain forest. *Journal of Ecology*, **95**(4): 818–827.
- Tan, H. T. W., L. M. Chou, D. C. J. Yeo & P. K. L. Ng, 2010. *The Natural Heritage of Singapore*. 3rd Edition. Prentice Hall-Pearson Education South Asia Pte Ltd, Singapore, 323 pp.
- Teo, D. H. L., H. T. W. Tan., R. T. Corlett., C. M. Wong & S. K.Y. Lum, 2003. Continental rainforest fragments in Singapore resist invasion by exotic plants. *Journal of Biogeography*, **30**(2): 305–310.
- Teo, R. C. H. & S. Rajathurai, 1997. Mammals, reptiles and amphibians in the nature reserves of Singapore—diversity, abundance and distribution. *Gardens' Bulletin Singapore*, **49**(2): 353–425.
- Teo, R. C. H., 2004. Checklist of amphibians, reptiles and mammals of Pulau Ubin, Singapore. <http://www.nparks.gov.sg/cms/docs/Ubin-Vertebrate-List.doc>. (Accessed 10 May 2010).
- Ting, L., 2009. Wild boar: Eating in OK, trapping isn't. *The Straits Times*, 12 Jul.2009. <http://wildsingaporenews.blogspot.com/2009/07/wild-boar-eating-is-ok-trapping-isnt.html>. (Accessed 10 May 2010).
- Ting, T. S. & J. Ng, 2004. Wild boar spotted at Changi golf club. *Channel NewsAsia*, 11 May 2004.
- Wallace, A. R., 1895. *Island Life: or the Phenomena and Causes of Insular Faunas and Floras including a Revision and Attempted Solution of the Problem of Geological Climates*. 2nd Edition. MacMillan and Co, London and New York. Pp. 73.
- Yang, C. M., K. Yong & K. K. P. Lim, 1990. Wild mammals of Singapore. In Chou, L. M. & P. K. L. Ng, (eds.), *Essays in Zoology*. Department of Zoology, National University of Singapore, Singapore. Pp. 1–23.