PRELIMINARY STUDY OF INTRODUCTION OF BARN OWLS (*Tyto alba javanica*) IN PULAU RAWA AND THEIR INTERACTION WITH RAT POPULATIONS ON THE ISLAND

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by

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LIST OF SYMBOLS

g	gram
mm	millimetre
cm	centimetre
m	metre
km	kilometre
ha	hectare
MHz	megahertz

LIST OF ABBREVIATIONS

IUCN	International Union for Conservation of Nature
DWNP	Department of Wildlife and National Parks
VHF	Very-high Frequency
GPS	Global Positioning System
MCP	Minimum Convex Polygon
HM	Harmonic Mean

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KAJIAN AWAL PENGENALAN BURUNG PUNGGUK JELAPANG (*Tyto alba javanica*) DI PULAU RAWA DAN INTERAKSINYA DENGAN POPULASI TIKUS DI PULAU

ABSTRAK

Kajian ini dijalankan untuk memperkenalkan Burung Pungguk Jelapang (*Tyto alba javanica*) ke Pulau Rawa dan mengkaji interaksinya dengan populasi tikus di pulau tersebut. Sembilan ekor burung dengan empat latar belakang yang berbeza dilepaskan secara berkala di Pulau Rawa dalam tempoh satu tahun kajian. Sembilan ekor burung tersebut terdiri daripada burung dewasa liar (*n*=2), burung dewasa muda liar (*n*=2), burung yang dibesarkan di dalam aviari (*n*=2), dan burung yang dibela separa jinak (*n*=3). Pelepasan burung pungguk jelapang dianggap berjaya apabila burung dapat dijejaki melebihi 30 hari selepas pelepasan. Semua burung dewasa liar dan burung yang dibela separa jinak berjaya dijejaki lebih dari dua minggu tetapi kurang daripada 30 hari selepas dilepaskan, dan seekor burung betina yang dibela separa jinak dijejaki lebih dari 30 hari pasca-pelepasan. Selebihnya (*n*=4) telah dijejaki kurang daripada dua minggu pasca-pelepasan. Sekiranya keputusan penjejakan radio mencukupi, lakuan pegerakan burung-burung yang dilepas, iaitu julat rumah, kawasan teras, kawasan digunakan, keutamaan habitat, tempat hinggap dan pegerakan dianalisasi. Kaedah tangkapan tikus hidup, yang berhubungan dengan pelepasan burung hantu, dijalankan di tiga tapak tangkapan di sepanjang kajian dan kadar tangkapan digunakan sebagai indeks untuk menganggar populasi tikus di pulau. Burung dewasa liar (*n*=2) mempunyai purata julat rumah sebanyak 0.039 km^2 (± 0.014 km^2) dan purata kawasan teras sebanyak 0.0055 km^2 (±0.0002 km^2). Burung yang dibela separa jinak (*n*=2) memilik purata julat rumah sebanyak 0.035 km^2 (±0.003

km^2) dan memiliki purata kawasan teras sebanyak 0.002 km^2 (±0.0001 km^2). Habitat pilihan dalam pulau dan dalam julat rumah untuk kebanyakan burung adalah kawasan hutan dan tempat hinggap pilihan untuk semua burung adalah pokok di dalam kawasan hutan. Berbanding dengan burung lain, burung yang dibela separa jinak memiliki keutamaan habitat dan tempat hinggap relatif tinggi di kawasan komersial pulau. Keputusan ini, sekali dengan tempoh masa lama burung yang dibela separa jinak dijejaki di pulau selepas pelepasan, menunjukkan bahawa burung yang dibela separa jinak adalah yang paling sesuai untuk diperkenalkan di pulau tropika kecil dengan gangguan manusia yang minima. Dua spesis tikus telah dikenalpasti di sepanjang kajian; *Rattus tiomanicus* dan *Rattus rattus diardii*. Kadar tangkapan adalah paling tinggi di semua tapak tangkapan semasa tangkapan pertama di awal kajian sebelum burung pungguk dilepaskan. Kadar kelimpahan relatif tikus di ketiga-tiga tapak kajian turun selepas sesi tangkapan pertama dan berubah-ubah tanpa corak yang jelas di semua tapak sepanjang sesi tangkapan yang lain. Kadar kelimpahan tikus di hampir semua kawasan tangkapan yang dilingkungi julat rumah burung yang akan mempunyai impak penurunan, iaitu burung yang kekal di pulau selama dua minggu dan lebih, menurun selepas pelepasan burung-burung ini.

PRELIMINARY STUDY OF INTRODUCTION OF BARN OWLS (*Tyto alba javanica*) IN PULAU RAWA AND THEIR INTERACTION WITH RAT POPULATIONS ON THE ISLAND

ABSTRACT

This study was carried out to introduce Southeast Asian barn owls (*Tyto alba javanica*) to the island of Pulau Rawa and to study their interaction with the rat population on the island. Nine barn owls of four different backgrounds were introduced on the island intermittently throughout the one-year study period. The nine owls consisted of wild adult owls (*n*=2), wild fledglings (*n*=2), captive-held owls (*n*=2) and hand-reared owls (*n*=3). Barn owl releases were considered successful when owls were traceable more than 30 days after release. All wild adult owls and hand-reared owls were tracked for more than two weeks but less than 30 days post-release, and one female hand-reared owl was tracked for more than 30 days post-release and throughout the study. The remaining owls (*n*=4) were tracked less than two weeks post-release. When tracking results were sufficient, ranging behaviour of released owls, i.e. home range, core area, area of use, habitat preference, roost sites and movement, were analysed. Live-trapping of rats in relation to barn owl releases were carried out at three trapping sites throughout the study and capture rate was used as an index to estimate the rat abundance on the island. Wild adult owls (*n*=2) had an average home range of 0.039 km^2 (± 0.014 km^2) and an average core area of 0.0055 km^2 (±0.0002 km^2). Hand-reared owls (*n*=2) had an average estimated home range of 0.035 km^2 (±0.003 km^2) and an average core area of 0.002 km^2 (±0.0001 km^2). The preferred habitat within the island and within the home range for most owls were forest areas and the most preferred roost sites for all owls were trees within the forest. Compared to other owls,

released hand-reared owls had a higher relative habitat preference and roost site occupancy in commercial areas on the island. These results, along with hand-reared owls remaining on the island longest after release, indicate that hand-reared owls are the most suitable owls to be released in a small tropical island with minimal human disturbance. Two rat species were captured throughout the study; *Rattus tiomanicus* and *Rattus rattus diardii*. Capture rate was highest at all sites during the first trapping session at the beginning of the study prior to any barn owl releases. The relative rat abundance at all three sites dropped after the first trapping session and fluctuated without a clear pattern at the trapping sites during the remaining trapping sessions. The capture rate at most trapping sites encompassed in the home range of owls whose release would have an impact, i.e. owls that remained on the island for longer than two weeks, decreased following the release of these owls.

CHAPTER 1
INTRODUCTION

1.1 Overview of Study

Barn owls, *Tyto alba*, are from the family Tytonidae, a group made up of barn owls, bay owls and grass owls. Barn owls have an almost global distribution, with exceptions being Antarctica and several small islands (Taylor, 1994). Molecular work (Wink & Heidrich, 2000; Wink *et al*., 2004, 2008) has led to the definition of 25 subspecies of genus *Tyto* (König *et al*., 2008) that can be widely distributed to three species: the American barn owl, *Tyto alba furcata*, the Australian barn owl, *Tyto delicatula*, and the common barn owl *T. alba* which is distributed throughout most of Africa, Eurasia, and parts of South-east Asia. Barn owls are medium-sized owls, ranging from orange-buff to brown in colour plumage on their upperparts (Taylor, 1994). Their facial discs, underwings and underparts are paler in colour, usually white. The three wide-ranging species differ in appearance such as overall size, the degree of dark-redness, and the number and size of black spots, to name a few (König *et al*., 2008).

The Southeast Asian subspecies of barn owl, *Tyto alba javanica*, was first reported in Peninsular Malaysia in the late 1800s (Kelham, 1881; Gibson-Hill, 1949) and are thought to be from Java or Sumatra (Wells, 1972). The first nest was recorded in the attic of a house on an oil palm estate in Kulai, Johor in 1969 by Wells (Wells, 1972). Since then, this species has achieved a status change from "very rare" to "common" in Peninsular Malaysia (Duckett, 1984; Cik Mohd Rizuan *et al*., 2016). Today it is a common sight in oil palm plantations and rice fields where there is an abundant food source as well as available nesting boxes (Duckett, 1986; Lee, 1997).

Barn owls are the most frequently used avian predator in biological control (Labuschagne *et al*., 2016). Their versatility in nest site selection (Colvin, 1985; Lee, 1997) and lack of territorial behaviour display (Hafidzi *et al*., 2003; Smith *et al*., 2014) make it easy to utilize barn owls for the purpose of biological control. Despite their relatively small size, barn owls have a relatively high consumption rate and have been reported to eat up to one fourth of their body weight daily (Marti *et al*., 2005).

1.2 Rationale of Study

Various barn owl programs have been established worldwide, including in Malaysia. Barn owls are typically utilized as biocontrol agents in rice fields (e.g. Wood & Fee, 2003), and oil palm plantations (e.g. Duckett, 1976) in Malaysia, row crops (e.g. Meyrom *et al*., 2009), vineyards (e.g. Wendt & Johnson, 2017) and orchards worldwide (Askham, 1990; Taylor, 1994). Most barn owl programmes simply involve the manipulation of the owl population by the supplementation of nesting boxes (e.g. Duckett, 1976; Martin, 2009; Wendt & Johnson, 2017). Once established, the owls hugely increase the levels of predation pressure on the rodent population, and reduce the rodent numbers both by killing and consuming large numbers of rats.

1.3 Objectives of Study

The main objective of this research was to investigate the best method to introduce barn owls to an island. The study site, Pulau Rawa, is a small island with no previous reports or observations of resident barn owls. Therefore, this study can provide information on a successful method for the introduction and establishment of barn owls. As the study site is a small, closed population, it is easier to study the impact of barn owls on local rodent populations, compared to larger scale studies.

The objectives of this research are as follows:

i) To introduce and establish Southeast Asian barn owls, *Tyto alba javanica*, on the tropical island of Pulau Rawa, Johor, Malaysia,

ii) To study the ranging behaviour of different backgrounds of owls when released on a tropical island.

iii) To study possible impacts of released barn owls to rats on Pulau Rawa.

CHAPTER 2

LITERATURE REVIEW

2.1 Barn Owl Biology

Early investigations indicated that population densities of barn owls were limited by available nest sites (Duckett, 1976) and that many adult birds in estate populations were not breeding because of lack of nest sites (Duckett, 1991). Lenton (1980) showed that artificial nest boxes were accepted by barn owls and population densities of barn owls increased with a rise in available nest sites. The rapid spread of the barn owl subspecies *T. alba javanica* in Malaysia is associated with the spread of oil palm plantations (Lenton, 1984), an abundant food source of rodents as well as the availability of nesting boxes in oil palm plantations and rice fields (Duckett, 1986; Lee, 1997).

The lifespan of *T. alba javanica* in Malaysia is around 8 to 10 years (Lenton, 1980), while lifespan of wild barn owls *Tyto alba alba* in United Kingdom has been reported to average 2 to 5 years (Shawyer, 2011) though there are records of barn owls living up to 15 years (Shawyer, 2011). Barn owls have an almost global distribution and are often found in open habitats in tropical and temperate regions (Taylor, 1994). However their numbers are declining in some countries such as the United Kingdom and Canada (COSEWIC, 2010; CIEEM, 2013). *Tyto alba* is listed under the category of Least Concern in the IUCN Red List (2000) and are under CITES Appendix II. In Malaysia, under Act 716 of the Wildlife Conservation Act 2010, *T. alba* is listed a Second Schedule species, i.e. hunting and possession of parts without a special permit could lead to a fine and/or imprisonment upon conviction. Additionally, under the Wildlife Conservation Act 2010 (License, Permit and Special Permit Fees)

[Amendment] Regulations 2013, a research permit is needed to study the species. While a common sight in Peninsular Malaysia, the natural presence of *T. alba javanica* has not been recorded in Sabah and Sarawak (Taylor, 1994; Cik Mohd Rizuan *et al*., 2016).

2.1.1 Home range of barn owls

Akin to other owls, *T. alba javanica* are nocturnal predators but are "not territorial in hunting areas and would happily co-exist in close proximity" (Duckett, 1991). Reports of barn owl ranges differ among various regions and large variation in range sizes most probably reflect prey abundance in the respective habitat (Hafidzi *et al*., 2003). Barn owls in North America have been reported to have home ranges of 436 to 1,414 ha (Colvin, 1984) in Ohio, while Marti et al. (2005) reported a range of 283 to 688 ha. In Canada, Hindmarch et al. (2017) reported home range of barn owls are 100 to 2,850 ha. In England, Taylor (1994) recorded home ranges of 245 to 393 ha while Roulin (2002) reported a range from 90 to 465 ha, while barn owl fledglings have a home range of 1,600 to 4,200 ha in England (Meek *et al*., 2003). Karapan (2012) reported that in Thailand, released male fledglings had a range of 26 to 91 ha, while released female fledglings had a range of 21 to 246 ha.

Home ranges of *T. alba javanica* in Malaysia are smaller than those in temperate regions. Female barn owls in Malaysian oil palm plantations have been recorded to range at 2.16 ha (Norsham, 1987) and in rice fields the range is from 0.6 to 18.84 ha (Hafidzi *et al*., 2003; Naim, 2004). Lenton (1980) reported male barn owls in oil palms had a home range of 20 to 78 ha during the non-breeding season and 142 ha during breeding season. In rice fields, male barn owls home range was reported ranging from 34.14 to 41.5 ha (Hafidzi *et al*, 2003; Naim, 2004).

Dispersal of owls vary among studies reviewed. Marti (1999) reported an average natal dispersal of 102.9 ± 162.03 km from natal sites, with female owls traveling significantly farther than male owls. Marti (1999) also recorded the average breeding dispersal as 2.28 ± 1.77 km with no significant difference between males and females. Taylor (1994) reported short natal dispersal, i.e. less than 20 km, for nestlings in Scotland, with the longest dispersal recorded as less than 200 km (Bunn *et al*. 1982; de Bruijn, 1994; Marti, 1999). Marti (1999) noted that weather and population density were not significant factors in dispersal.

Hafidzi et al. (2003) reported that breeding females avoided each other and needed an exclusive 100 m circular core area around their nest. Shawyer (1998) also reported that during breeding season, barn owls showed signs of territoriality in a 5 to 100 m radius around their nest. In Malaysia, Lenton (1980) reported that owls bred successfully in an oil palm plantation with nest boxes which were only 50 m apart. Lenton (1980) and Meek et al. (2003) also reported overlapping of home ranges among owls with seemingly no effect on foraging and breeding success, and that owls defend their territories less when there is higher density of owls. Barn owl colonies elsewhere have also been observed to have overlapping home ranges (e.g. Karapan, 2012; Hindmarch *et al*., 2017).

2.1.2 Diet of barn owls

Barn owls swallow their prey whole but are unable to digest the fur, feathers or bones (Taylor, 1994) as their stomach pH is higher (less acidic) than other predatory birds, leaving soft bones of their prey undigested (Smith & Richmond, 1972). They cough up or regurgitate the undigested parts as a dark odourless lump called a pellet. Examination of these pellets have been used in a range of studies to identify prey items

of barn owls (e.g. Álvarez-Castañeda *et al*., 2004; Flikweert *et al*., 2007; Rocha *et al*., 2011; Hindmarch *et al*., 2017), as well as to study local small mammal populations (e.g. Magrini & Facure, 2008; Meek *et al*., 2012; Vale-Gonçalves *et al*., 2015; Lyman *et al*., 2016). Barn owl pellets have also been used to study patterns of geographical distribution (Barbosa *et al*., 1992), and temporal changes in prey communities (e.g. Love *et al*., 2000).

Barn owls feed on small mammals, birds, lizards, amphibians and insects (e.g. Taylor, 1994; Work & Hale, 1996; Álvarez-Castañeda *et al*., 2004; Fikweert *et al*., 2007; Martin, 2009; Rocha *et al*., 2011; Vale-Gonçalves *et al*., 2015). It is a generally agreed consensus that the main prey of barn owls are small mammals, however some studies show barn owls relying less on them. For example, Work and Hale (1996) and Fitzsimons et al. (2008) reported insects making up a high percentage of barn owl diets in Hawaiian Islands and Northern Victoria, Australia respectively.

Barn owls in tropical climates tend to have a relatively stable prey species population throughout the year (Taylor, 1994). Studies of barn owl diets in tropical Brazil and subtropical Argentina reveal barn owls feed mainly on Sigmodontinae rodents (Bellocq, 2000; Magrini & Facure, 2008; Rocha *et al*., 2011). Birds, bats and marsupials make up the rest of barn owl diets in Brazil and Argentina, with reptiles and amphibians rarely present (e.g, Bellocq, 2000). In Malaysia, most studies report that the diet of *T. alba javanica* is composed more than 90% of rats (Smal, 1990; Naim, 2004; Puan *et al*., 2011), with barn owls also preying on shrews, squirrels, birds and lizards in smaller numbers (Smal, 1990; Naim, 2004).

In tropical islands in the Caribbean, rodents make up the major prey of barn owls with bats and birds being preyed in smaller amounts (e.g. Buden, 1974; Debrot *et al*., 2001; Flikweert *et al*., 2007; Wiley, 2010). Insects and reptiles are also preyed on a few islands in Australia (Buden, 1974; Debrot *et al*., 2001; Flikweert *et al*., 2007). On more arid tropical islands, barn owls are reported to have a larger proportion of non-mammalian prey (Flikweert *et al*., 2007; Velarde *et al*., 2007). On Mediterranean islands of Greece, 90% of barn owl prey consisted of small mammals, while birds and amphibians make up the remaining 10% (Guerra *et al*., 2014). On the tropical Comoros islands, commensal rats were reported to make up more than 90% of barn owl prey (Stevens *et al*., 1999).

Comparison of barn owl diets on mainland and surrounding islands showed that barn owls on islands consume more bird species than mainland barn owls (Johnston & Hill, 1987; Guerra *et al*., 2014). However, the number of bird species on islands are significantly more than birds on mainland sites (Johnston & Hill, 1987), especially when islands are nearer to the equator (Johnston & Hill, 1987). Johnston and Hill (1987) suggested that this difference in barn owl diets is simply because of the relative number of birds on islands are higher than small mammals, hence birds are preyed on more.

2.1.3 Barn owl interspecific interactions

In Asia, barn owls have been reported to experience competition for nesting sites from rock pigeons and common mynas (*Acridotheres tristis)* (Santhanakrishnan *et al*., 2011). Barn owls have also been reported to be mobbed by American crows (*Corvus brachyrhynchos*), common mynas and common babblers (*Turdoides caudatus*) when discovered during the day (The Illinois Barn Owl Recovery Team,

2010; Santhanakrishnan *et al*., 2011). Known predators of barn owls are great horned owls (*Bubo virginianus*) and red-tailed hawks (*Buteo jamaicensis*) (Ontario Barn Owl Recovery Team, 2010; The Illinois Barn Owl Recovery Team, 2010). Ehresman et al. (1998) reported that great horned owls killed about one-half of captive-raised and released barn owls.

Interference interaction between barn owls and diurnal raptors are usually avoided. Leveau et al. (2004) studied the prey and activity period of the diurnal white-tailed kites *(Elanus leucurus*) and nocturnal barn owls (*Tyto alba*) in Buenos Aires, Argentina and concluded that although there is a trophic overlap of food, the different hunting period of both raptors avoided interference interactions among the two raptors. There was no apparent nest site competition either since both raptors have differing choice of nest sites (Leveau *et al*., 2004). Scheibler (2007) and Muñoz-Pedreros et al. (2016) reported similar overlap in food-niches of white-tailed kites and barn owls in Brazil and Chile respectively but no apparent interference interaction. However, it is suggested that there would be competition for food if prey numbers would fall as there is a trophic overlap of 80% between the two species (Simeone, 1995, as cited in Leveau *et al*., 2004).

Several studies have also been conducted to compare the diet of barn owls with other nocturnal raptor species. The studies of barn owls alongside raptors in various regions record habitat overlap and significant dietary overlap in mammalian prey, however no interference interaction is reported between the raptors (Gotta & Pigozzi, 1997; Goutner & Alivizatos, 2003; Pavey *et al*., 2008; Kopij *et al*., 2014; Milchev, 2016). Barn owls have also been observed breeding in close proximity with other raptors. Pavey et al. (2008) studied letter-winged kite (*Elanus scriptus*) and barn owl (*Tyto alba*) in arid/semi-arid Australia and recorded that the two species roost within

one km of each other. However, this overlap was only observed when rodent density was high (Pavey *et al*., 2008). Milchev (2016) who studied interaction between barn owls (*Tyto alba*) and eagle owls (*Bubo Bubo*) in Bulgaria reported barn owls breeding in close proximity with eagle owls suffered no impact on their breeding, however there were some cases of predation of barn owl by eagle owls.

2.2 Barn Owl and Rodent Interaction

Biological control involves the suppression of one organism by another for the purpose of eradication and/or control of invasive alien species (Cook & Baker, 1983) and barn owls are the most frequently used avian predator in biological control (Labuschagne *et al*., 2016). Once established, the owls hugely increase the levels of predation pressure on the rodent population, and reduce the rodent numbers both by killing and consuming them. Labuschagne et al. (2016) reviewed numerous studies on avian predation to control rodents and concluded that avian predators can produce measurable effects on pests and can cause decline in pest capture success and associated crop damage.

Barn owl programs have been successfully established in various agricultural fields such as sugarcane fields (e.g. Martin, 2009) vineyards (e.g. Van Vuren *et al*., 1998; Wendt & Johnson, 2017), and alfalfa fields (e.g. Motro, 2017). In Malaysia, *T. alba javanica* have long been used as a method of bio-control of rodent populations in oil palm plantations and rice fields since 1969 (Duckett, 1986; Hamid *et al*., 2010). Basri et al. (1996) reported that in 188 oil palm plantations in Malaysia where barn owl boxes were built, there was a decline in rat numbers and damage. Ho and Teh (1997) reported lower rodent damage in a 500 ha area of 20 to 22 year old palms with 1 nest-box per 10 ha. Chung et al. (1995) reported a decrease in rat activity in a study

area with barn owls present. Heru et al. (2000) relied solely on owl establishment for rat control on estates covering over 32,000 ha and reported relatively low damage and rat numbers, with suggestion of a trend to continuing decline. A study by Puan et al. (2011) on an oil palm estate showed that barn owls preyed mostly on small mammals and 95.1% of prey were rodents. Mohamad and Goh (1991) reported that erecting barn owl boxes in rice fields reduced rat damage from about 6.5% to 2.5%. However, it should be noted that parameters to assess rat damage in oil palms are flawed (Wood & Fee, 2003).

Contradicting the few examples listed above, some studies report barn owls are not a sufficient means of rat control in agricultural fields. In his two-year study of barn owl control of rodents in sugarcane fields, Martin (2009) reported that despite preying mostly on the rodent pests, barn owls failed to control the abundance of the rats. He hypothesized that the high reproductive capability of rats probably exceeded the removal rate by owl predation and that rats removed by owls were likely replaced by rats moving in from surrounding landscape. Verwilghen (2015) who studied the relationship between barn owls and rodents in oil palm plantations in Indonesia reported that barn owls alone could not regulate rat populations. Noor Hisham et al. (2013) reported that barn owls were insufficient in controlling rodents in young and newly planted oil palm fields.

Some researchers are of the opinion that lack of concrete evidence does not mean barn owls serve as sufficient biological control (e.g. Wood & Fee, 2003). Studies of barn owls that have been reported are typically of short duration to detect population changes, and these studies require continued and long-term investigations (Hafidzi & Na'im, 2003; Wood & Fee, 2003; Martin, 2009). There are several researchers that state barn owl programs would be more successful with complementary baiting (Lam,

1982; Duckett, 1984; Wood & Fee, 2003; Noor Hisham *et al*., 2013). Estates that carried out baiting and barn owl control simultaneously reported a 50 to 68% reduction in baiting requirements (Hafidzi & Saayon, 2001; Noor Hisham & Samsudin, 2004) and reduction in baiting campaigns (Hafidzi & Saayon, 2001).

2.3 Translocation of Barn Owls

The definition of 'translocation' by IUCN (2013) is "the human-mediated movement of living organisms from one area, with release in another". Barn owl introductions to new habitats for the purpose of biological control falls under the category of ecological replacement. Ecological replacement is defined as "the intentional movement and release of an organism outside its indigenous range to perform a specific ecological function" (IUCN, 2013). Reintroduction programmes have potential benefits for small populations such as increasing the number of animals, increasing genetic diversity, reducing inbreeding depression and establishing new populations (Scott & Carpenter, 1987). Opposition issues to barn owl reintroduction schemes summarized by Meek et al. (2003) are: (1) animal welfare; (2) disease introduction to wildlife populations by the released individuals, as well as competition for food and habitat; (3) difficult integration between captive birds and wild birds due to behavioural or physiological differences, (4) no resulting conservation benefit or population increase, and (5) the genetic consequences of releasing captive-bred barn owls. Nonetheless, reintroduction programmes have been successful for several species of birds such as Peregrine Falcons (*Falco peregrinus*), Masked Bobwhite (*Colinus virginianus ridgwayi*), and Puerto Rican Parrots (*Amazona vittata*) (Scott & Carpenter, 1987).

2.3.1 Barn owl introduction to islands

Two barn owl island introductions will be highlighted here; introduction to the Seychelles islands and Hawaiian islands. In the 1950s, barn owls *Tyto alba affinis* were introduced on a few Seychelles Islands from East Africa to control the black rat (*Rattus rattus*) population in coconut plantations (Beaver & Mougal, 2009). The owls were successfully breeding by 1956 and studies of pellets showed that barn owls were preying on rats (80%) and fairy terns (*Gygis alba*), an endemic species (Seychelles government agricultural reports, cited in Beaver & Mougal, 2009). The barn owl status changed to "pest" due to owls preying on fairy terns and the declaration that they had a relatively small impact on rat populations (Beaver & Mougal, 2009, Fanchette, 2012). A reversal policy by the Seychelles government in the late 1960s introduced monetary bounty being offered per dead owl in an effort by the government to eradicate barn owls (Beaver & Mougal, 2009). To date, barn owls have reportedly been successfully removed from two islands: Aride and Cousin (Fanchette, 2012).

Introduction of barn owls to the Hawaiian Islands for the purpose of rodent control began in 1958 (Thistle, 1959). Barn owls were translocated from California and Texas to the islands of Kauaʻi, Hawaiʻi, Oʻahu, and Molokaʻi from 1958 to 1963 (Thistle, 1959; Tomich, 1962, Berger, 1981). However, like the barn owls introduced on the Seychelles, barn owls are now considered a serious threat to native seabirds, despite barn owls preying on Polynesian rats and feral rabbits, both species that are considered pests (VanderWerf *et al*., 2007). Barn owls have been removed from Kaʻula island and there are recommendations for similar steps to be taken in Lehua and Kauaʻi islands (VanderWerf *et al*., 2007; Raine *et al*., 2017).

In Malaysia, the first translocation programme of barn owls from Peninsular Malaysia to Sabah on the island of Borneo, was carried out from 1990 to 1992 (Hoong, 2000), followed by another translocation programme in 2003 to Sarawak and Sabah (Cik Mohd Rizuan *et al*., 2016). In 2017, Cik Mohd Rizuan et al. reported that two pairs of translocated owls had successfully bred in Lahad Datu, Sabah. Both breeding pairs produced two clutches in a year. In total, 64.3% of juvenile barn owls were reported from five breeding counts and 55% of these juveniles fledged.

2.3.2 Barn owl release

Adequate nest boxes erected at suitable habitats prior to release is a vital factor in barn owl programs (e.g., The Barn Owl Trust, 1989a; Meek *et al*., 2003). The release site for barn owls must be an area of suitable habitat, supporting a good population of small mammals, at least 8 ha in size (Karapan, 2012) and absent of wild barn owls (The Barn Owl Trust, 1989c). The release site should also be far away from major roads (The Barn Owl Trust, 1989b) and absent of potential hazards to barn owls such as rodenticide usage and open tanks that can cause drowning (Ramsden, 2004).

Captive breeding and release is defined by Green and Ramsden (2001) as "the deliberate release of captive-bred birds into an area from which the wild population has been lost entirely (reintroduction) to establish a self-sustaining and viable population in the long term, or to supplement an existing threatened population (restocking) to increase the overall viability of the wild population". Captive owls selected for release should be wild, unrelated, in healthy condition and not be more than three years old (Meek *et al*., 2003; Karapan, 2012). Semi-tame barn owls that call for food when they see or hear their human caretaker can still be released as this

behaviour normally stops once birds are transferred into the release site (The Barn Owl Trust, 1989d).

In temperate Britain, 67% of the release of captive bred owls were done in the spring and summer, with a few releases carried out relatively late in the year in the months of September and October (Green & Ramsden, 2001). In a tropical region, Karapan (2012) recommends that barn owls be released before the breeding season so that the owls have more time to adapt to their new environment before breeding. Release should be at dusk when the weather is good, i.e. dry weather with little wind, no fog and good weather forecast (The Barn Owl Trust, 1989c).

The Barn Owl Trust (1989 b,c,d) lists two method of release of captive owls: the 'Long Term' release method and the 'Young Brood' (also called 'Young Clutch') method. The Long Term release takes around 7 months (The Barn Owl Trust, 1989b) while the Young Brood method takes about 2 months (The Barn Owl Trust, 1989b). Another method is the 'short term' release method (Meek *et al.*, 2003) where a pair of owls are placed in a breeding box from which they cannot escape. The owls are released after a short period of captivity, usually about then 10 days. However, this method was concluded as unproductive by Meek et al. (2003) who carried out 16 releases using this method and reported most adults deserted their release sites and only 3 sites had young that fledged.

2.3.2(a) The 'long term' release method

The 'Long Term' release method (Ratcliffe, 1979; Bunn *et al.*, 1982; The Barn Owl Trust, 1989c) aims to establish a pair of barn owls at or near the release site with the intention that they will breed. A pair of captive-bred adult owls are introduced into a suitable building big enough for them to fly around in, where they are confined for

up to six months (The Barn Owl Trust, 1989c). It is preferred to release a male and female pair that have already chosen each other (can be identified by them roosting side by side) (The Barn Owl Trust, 1989c). They are fed every day and it is hoped that the adult owls will breed in captivity at the release site (The Barn Owl Trust, 1989c; Meek *et al*., 2003).

When the youngest owlet is four to six weeks old and capable of eating food whole, the adults are allowed access to the outside world based on the assumption that the parents will not desert the unfledged young (Meek *et al*., 2003). However, Meek et al. (2003) reported that 50% of adults left the nest and never returned. In cases of abandonment, the young are then fed by volunteers until fledgling and or till winter if the birds are still in vicinity of the release site even after fledging. The owlets fledge about four weeks after the release of adults and then disperse naturally (The Barn Owl Trust, 1989c). Although many pairs of owls bred successfully in their places of release, many deserted their release sites soon after being set free (Meek *et al*., 2003). Desertion was still reported even when the period of adult captivity was increased (Meek *et al.*, 2003).

2.3.2(b) The 'young brood' release method

The 'Young Brood' or 'Young Clutch' release method is where young barn owls around four to six weeks old are placed in a nest-box in a suitable building with good habitat nearby (The Barn Owl Trust, 1989d). The young barn owls are fed and a food return pattern is easily normally established with supplementary food being provided until the owls are self-sufficient, usually at about 14 weeks old (The Barn Owl Trust, 1989d). Meyer (2008) introduced barn owls in a semi-urban area in South Africa using the 'Young Brood' release method. Meyer managed to establish a food

return pattern for the young owls and she reported that the supplementary feeding gave the owls time to improve their flying and learn how to hunt efficiently. Meyer also reported that released owls frequently returned to the nest-box for food in the first week after release but their returns gradually decreased and supplementary feeding was eventually stopped within 14 days after owl release. Additionally, her study indicated that introduced owls had an impact on rat numbers since trapped rats were significantly fewer at owl sites compared to sites where owls were absent.

Unlike the 'long term' release method, young owls in the 'young brood' release are not confined to the release sites, and their speed of release is governed by their natural pace of development (The Barn Owl Trust, 1989b,d; Green & Ramsden, 2001). The young are able to develop their prey-catching skills near release sites while being supported by supplementary feeding and hence the gradual release is relatively safe (Green & Ramsden, 2001). The 'long term' method takes more work and time than the 'young brood' method, however it has a higher chance of resulting in the establishment of a breeding pair (The Barn Owl Trust, 1989d).

2.4 Sampling Methods

2.4.1 Relative index method

Density of a population can be obtained via relative index methods or statistical estimators. An abundance index is an incomplete count of individuals that is assumed to be proportional to the true abundance (Conroy, 1996). An abundance index is a common tool to estimate population size (Slade & Blair, 2000; McKelvey & Pearson, 2001) and to monitor population changes to assess impact of a control program (Caughley, 1977). Indexing methods are generally easier to carry out and cost less compared to a direct count or statistical estimate (Conroy, 1996; Williams *et al*., 2002;

Greene, 2012). Most published studies of large population sizes generally conclude that estimators are preferable to indices because they result in less bias (e.g., Otis *et al*., 1978; Nichols & Pollock, 1983; McKelvey & Pearson, 2001). Indices can yield weaker interpretations because of poor sampling design, uncertain and/or untested relationships between indices and actual abundance and untested assumptions of homogeneity of detection probability (e.g., Thompson *et al*., 1998).

CHAPTER 3

METHODOLOGY

3.1 Study Site and Project Duration

Pulau Rawa is situated at the south of the east coast of Peninsular Malaysia, about 16 km from the coast of Mersing, Johor. The island is part of the Seribuat archipelago, which also includes the neighbouring Pulau Tioman. The habitat of the island is a mix of coastal shrub and sandy beach on the western side of the island and rocky outcrops and cliffs on the eastern side of the island, with secondary forest being the primary habitat. The island encompasses an approximate area of 0.27 km^2 (ArcGIS) (Figure 3.1). Being in a tropical region, the climate is typically hot and humid all year round and the annual monsoon season is typically from the month of October till the end of March.

Two resorts are located on the island; Rawa Island Resort and Alang's Rawa. These commercial resorts are the only human occupied area on the island. The island was gazetted under the Sultan Iskandar Marine Park of Johor in 1994 under the Fisheries Act 1985 (Amended 1993) in order to protect and conserve the habitat and various marine life.

This study was carried out from September 2016 till November 2017. Permit for this study was obtained from Department of Wildlife and National Parks Peninsular Malaysia (PERHILITAN) (reference number JPHL&TN(IP):100-34/1.24 Jld 7 (26)) (Appendix A).

Figure 3.1: Satellite image of Pulau Rawa obtained from Google Maps 2017

3.2 Introduction of Barn Owls

3.2.1 Nest-boxes

Two fiberglass nest-boxes were set up in the centre of the island. The nest-boxes measured 45 cm at maximum height, 48 cm at maximum width and 87 cm at maximum height, with a hideaway partition inside. The entrance of the nest-boxes were 24 cm x 20 cm. The nest-boxes were fixed on trees and the entrances led out to open area, with no dense vegetation obscuring the entrance. The first nest-box was set up in January 2017 near the general store (2° 31′ 15.93″ N, 103° 58′ 32.5″ E), 4.5m from the base of a tree (Plate 3.1.A). The second nest-box was set up in August 2017, 4.5m from the base of a tree as well. The approximate GPS coordinates of the tree is at latitude: 2° 31′ 15.85″ N and longitude: 103° 58′ 32.36″ E (Plate 3.1.B).

Plate 3.1: Nest-boxes installed on the island. A: First nest-box installed near the general store. B: Second nest-box installed in the forest, along the paved trail of the island. (Remarks: Nest-boxes are indicated by red squares)

3.2.2 Background of released barn owls

Barn owls released on Pulau Rawa had different backgrounds (Plate 3.2). All releases involved a pair of barn owls (except the last owl released), sexed on their morphological characteristics. All owls were harvested from rice fields of Bagan Serai, Perak (5.0081° N, 100.5394° E), with the exception of the last owl released that was harvested from rice fields of Tanjung Karang (3.4264° N, 101.1767° E). The following summarizes the barn owls released and their backgrounds:

i) First release: wild adult owls (ID: 01M and 01F) (Plate 3.2.A): These wild adult owls grew, mated and have bred in the wild. The nest-box they were collected from showed signs of recent breeding activity.

ii) Second release: wild fledglings (ID: 02M and 02F) (Plate 3.2.B): Released fledglings were raised in the wild by their natural parents and were harvested from their nest-boxes at approximately 70 days old, where their

plumage was that of an adult but the birds had yet to disperse from their natal nest-box.

iii) Third and fifth release: hand-reared owls (ID: 03F, 03M and 05M) (Plate 3.2.C): These hand-reared owlets were harvested from the rice fields of Bagan Serai (03F and 03M) and Tanjung Karang (05M). 03M was harvested at the age of approximately 9 days old while owls 03F and 05M were harvested at the age of approximately 20 days old. The age of the owlets were estimated using their plumage and physical abilities, i.e. amount of down feather, their eyes, head raising ability and ability to stand (Bunn & Warburton, 1977). The hand-reared owls were given non-hacking training before their release in order to better equip them to survive in the wild. Their flying skills were also given time to develop and they were only released once they were observed to be adept fliers.

iv) Fourth release: captive-held, semi-tame owls (04M and 04F) (Plate 3.2.D): These owls were harvested from rice fields of Bagan Serai when they were fledglings. They were raised in the USM aviary (5˚21'28.51″ N, 100˚17'39.26″ E) and trained with a non-hacking method for four months in the aviary before release on Pulau Rawa. These owls were observed roosting together, an indication they had mated, and so were released as a pair.

All owls were banded with metal bands (except hand-reared owls) around their legs, with numbers to assist in their identification (Plate 3.2 (E-F)). The owls were temporarily held in captivity for a few days before their release on the island. The owls were fed rats and mice while in captivity. Table 3.1 shows details of all the barn owls released on the island.

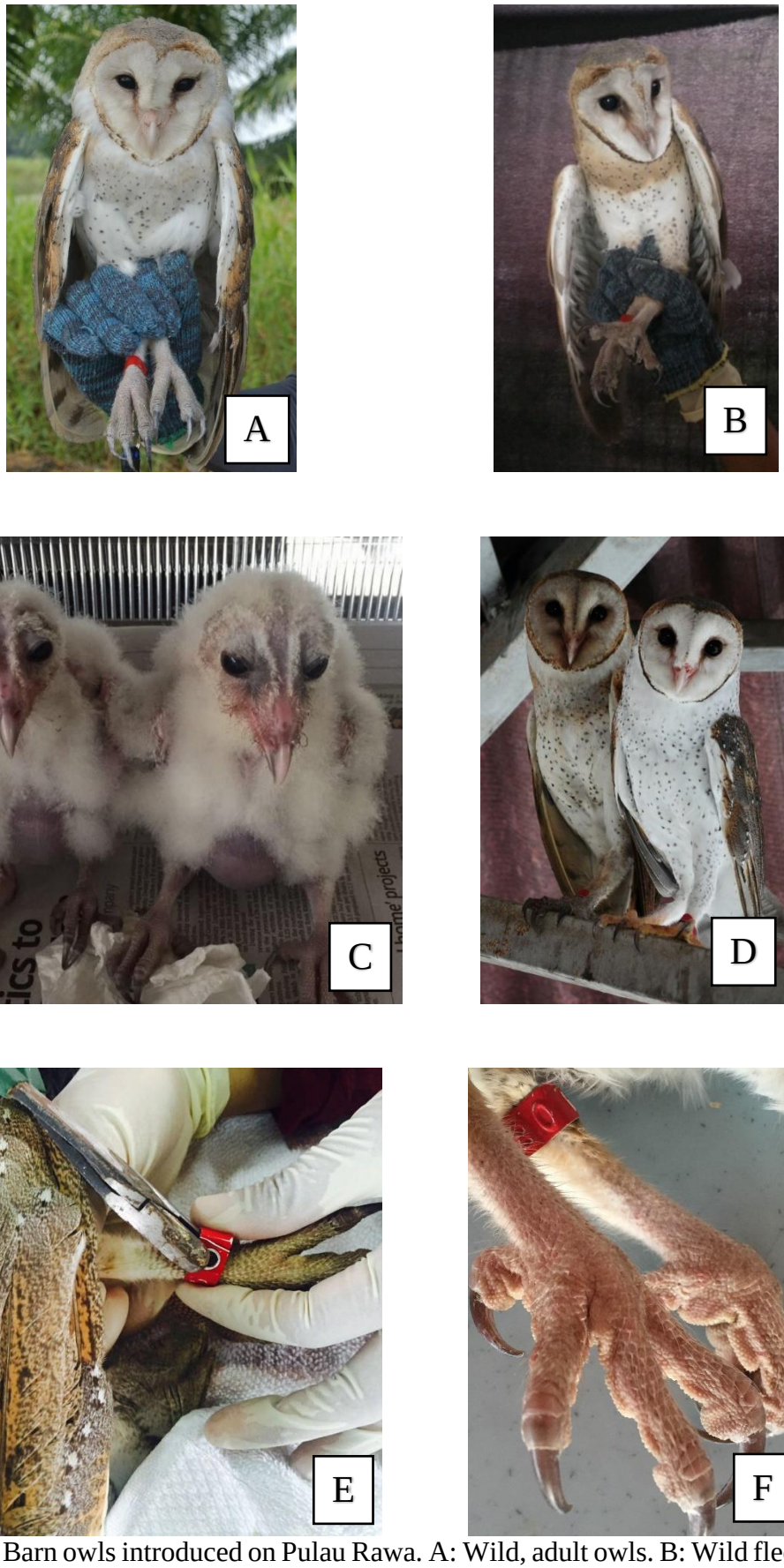

Plate 3.2: Barn owls introduced on Pulau Rawa. A: Wild, adult owls. B: Wild fledgling owls. C: Hand-reared owlets. D: Captive-raised, semi-tame owls. E: Banding of owls before release. F: Metal band with identification number on tarsus of owl.

Table 3.1: Barn owls introduced on Pulau Rawa

Owl release	Owl Code (Sex)	Owl band number	Transmitter frequency	Release date and time	Release site (Nest-box)
First	01M (Male)	173	150.034	7/2/2017, 2024	First
	01F (Female)	172	150.055	7/2/2017, 2030	First
Second	02M (Male)	179	150.044	21/4/2017, 0945	First
	02F (Female)	180	150.325	21/4/2017, 1000	First
Third	03M (Male)	185	150.385	25/6/2017, 1030	First
	03F (Female)	No band	150.346	25/6/2017, 1040	First
Fourth	04M (Male)	175	150.355	11/9/2017, 1545	Second
	04F (Female)	167	150.306	10/9/2017, 1820	Second
Fifth	05M (Male)	No tag	150.005	22/10/2017, 1405	First

The following is the release methods for each owl pairs:

i) First release (wild adult owls) (01M and 01F):

The owls were simply released at the ground of the base of the first nest-box at night. The male owl was released first, followed immediately by the release of the female owl.

ii) Second release (fledglings) (02M and 02F):

The owls were placed into the first nest-box in the daytime.

iii) Third release (hand-reared owls) (03M and 03F):

The owls were placed into the first nest-box in the daytime, with the nest-box entrance sealed.