CHAPTER 2: LITERATURE REVIEW

2.1 Intertidal Mudflats of Southeast Asia

Mudflat is also known as tidal flat. Tidal flats are intertidal, non-vegetated, soft sediment habitats, found between mean high-water and mean low-water spring tide cycles (Dyer et al. 2000; Smithsonian Institution 2010) and are generally located in estuaries and other low energy marine environment. They are distributed widely along coastline worldwide, accumulating fine grain sediments on gently sloping beds, forming the basic structure upon which coastal wetland build. Although tidal flats comprises only about 7% of total coastal shelf areas (Stutz and Pikey 2002; Smithsonian Institution 2010), they are highly productive components of shelf ecosystems responsible for recycling organic matter and nutrients from both terrestrial and marine sources and also areas of high primary productivity.

Depending on sediment grain size, tidal flats may be generally categorized into mudflats and sand flats. Generally, mudflats are located in the upper part of intertidal zone whereas sand flats are located in the lower part. Mudflats and sand flats in estuaries are vital feeding habitats for resident bird populations and provide important overwintering sites for migratory waders (Goss-Custard and Verboven 1993). Mudflats are highly productive environments and they can be viewed as the ‘pasturelands’ of the intertidal zone (The University of Sydney 2010). Furthermore, intertidal mudflats are important habitats for a large variety of animal and plant species. They perform many ecological functions by providing spawning grounds for fish, habitats for birds, reptiles and other important fauna as well as protecting the coastal zone from erosion (The University of Sydney 2010). Mudflats and sand flats are often utilized by bait collectors, the activities of whom have been found in some cases to affect shorebird populations.
(Townsend and O’Connor 1993; Shepherd and Sherman Boates 1999), or to have no effect on waders density or feeding technique (Navedo and Masero 2008).

The distribution, status and trends of intertidal mudflats are heavily impacted by human influence (Healy et al. 2002; Keddy 2010; Mackinnon et al. 2012). Throughout South-East Asia, mudflats and adjoining mangroves have been greatly reduced due to growing human population and corresponding demand for land. The current estimates of the rate of intertidal habitat loss in Asia are equal to or greater than recorded losses of mangroves (Giri et al. 2011), tropical forest (Achard et al. 2002) and sea grasses (Waycott et al. 2009). For example, over the past 50 years, losses of up to 51% of coastal wetlands have occurred in China (An et al. 2007), 40% in Japan, 60% in the Republic of Korea, and more than 70% in Singapore (Hilton and Manning 1995; Yee et al. 2010). This has reduced the number of refueling or staging points for migratory birds between breeding and wintering grounds.

Mudflats are a distinct feature of West Coast of Peninsular Malaysia which is sheltered from strong wave action, allowing substrate to be deposited along the coastline. This substrate comprises largely of the silt, sand, clay and decomposed organic matter which allows for the prolific growth of mangroves as well as small invertebrates and minute organisms to thrive. When exposed during low tide, mudflats offer good feeding places for a host of migratory shorebirds on ‘refueling’ stops as well as large numbers of herons and egrets as well as gulls and terns which roost in large numbers on the exposed mud (Jeyarajasingam 2012).
2.1.1 The importance of Intertidal Mudflats

Estuarine mudflats are very important for wader population during winter and migration. Many species of waders feed almost exclusively on intertidal benthic invertebrates at low tide. In temperate regions, species diversity of intertidal benthic invertebrates may be relatively low, but sediment that is rich in organic content may support exceedingly high densities – molluscs and polychaete worms can exceed 10,000 individuals per m\(^2\) (Barnes et al. 1997). On the contrary, in tropical regions, the biodiversity of benthic macrofauna on intertidal mudflats is much higher and the productivity rates are ten times higher than in temperate intertidal habitats (Alongi 1989). Therefore, the intertidal mudflats in tropics areas can thus be concluded as more valuable as it comprises of higher content of prey items for bird utilizing these areas. Study in the Inner Gulf of Thailand by Wetland International and the Bird Conservation Society, indicated that the intertidal mudflats, salt pans and abandoned shrimp ponds in this area are visited by an estimated of 80,000 to 100,000 of waders each year (Erftemeijer et al. 1999).

Apart from being vital habitat for the survival of millions of birds of more than a hundred species, intertidal habitats is also critical as nesting beaches for sea turtles, breeding areas for Asia’s seals, spawning grounds for important economic fisheries, and home of thousands of species of invertebrates (Mackinnon et al. 2012). Yusoff et al. (2006), reported that intertidal habitat are amongst the most productive ecosystems on earth which provide safe spawning areas and nurseries for countless species of fish and crustacean on which coastal fisheries depend. Similarly, Zulkifli et al. (2014), stated that this area provides important permanent and temporary habitats for a large number and range of marine and terrestrial fauna.
Furthermore, intertidal habitats functions as physical collecting zones of sand, mud, pebbles and fringe vegetation that help slow and break the action of waves. Gentle beaches tame ocean providing safe places for villagers, harbours and towns and the protection for adjacent agricultural areas (Mackinnon et al. 2012). Intertidal mudflats also important for the livelihood of coastal villagers whose collect shellfish and other products from the mudflats at low tide. Nielsen et al. (1998) reported the local exploitation of bivalve molluscs and crabs at the Cua Day Estuary in the Red River Delta in Vietnam, an area habituated by approximately of 39,000 peoples. They estimated that at least 200,000 man days were spent on collecting 1,600 tons of bivalves and 30 tons of crabs from a 3,350 ha area per year. Therefore, the intertidal mudflats area can be classified as crucial areas to generate incomes for people living near the shores.

In addition, healthy strand vegetation, sea grass beds, algal beds and mangroves, provide significant shelter in the face of typhoon and storms against the tsunami that are frequent in a zone prone to devastating earthquakes (Caldecott and Wickremasinghe 2005). Coastal damage seen after the great tsunami in Aceh, Indonesia in 2004 revealed that sites protected by intact healthy coral, mangrove or other coastal vegetation were dramatically less damaged than sites where the same habitats had been destroyed (Chang et al. 2006; Forbes and Broadhead 2007).

### 2.2 Wader in general

A total of 743 bird species were recorded in Malaysia (Malaysian Nature Society Bird Conservation Council 2015) and occurred in 9 types of habitats (Madoc 1985). The habitat are categorized as open seas, islands within open seas, coastal areas, mangroves,
freshwater swamps, rivers, urban or rural types of recreational parks, fields or bushes, forests and highland areas. Waders are an integral part of estuarine systems and are the subject of extensive conservation effort in many places in the world (Hill et al. 1997; Stroud et al. 2004; Durell et al. 2005). Waders depend on coastal and inland wetlands and can occur in large numbers at their non-breeding and staging sites (Lane 1987; Barter 2002).

Birds are found almost everywhere because they are very dynamic, can easily be seen and observed for several purposes (Joshi and Shrivastava 2012). Birds serve as excellent indicators of environmental health and change. They occupy a wide range of niches, use many types of food and physical resources, and are sensitive to environmental changes (Mackinnon et al. 2012). For example, birds have been used in Environmental Impact Assessment (E.I.A) because they are very sensitive to environmental changes (Joshi and Shrivastava 2012). Some birds are generally believed by local people to be both indicators of season and time, and to some extent certain bird species can be used to predict the period of the day and night, e.g., cock crows at dawn. Furthermore, birds are well-adapted to many diverse terrestrial and aquatic habitats. To study an ecosystem, the birds serve as important component as they have the ability to fly away and avoid any obnoxious condition. Hence, they are considered as important health indicators of the ecological conditions and productivity of an ecosystem (Newton 1995; Desai and Shanbhag 2007; Li and Mundkur 2007; Joshi and Shrivastava 2012).

Rapid development of Southeast Asia coastal plains over the last few decades has posed adverse effects on populations of waders through degradation of natural habitats essentials for water birds (Bakewell 2009). Results from Asian Water bird Census between 1987 and 2007 revealed an estimated reduction of over 22% water bird populations visiting Malaysia (Li et al. 2007). In addition, the wader numbers of the
West Coast of Peninsular Malaysia have declined dramatically. This applies particularly to Perak State and Selangor State of which the former has suffered a decline of 80% to 94% and the latter one of 50% over the last twenty years (Li et al. 2007). Based on survey conducted by Li et al. (2006), about 21,390 waders species were recorded in Selangor Coast from November 2004 until April 2005. This count is much lower than the total of 39,034 shorebirds recorded in 1985 until 1986 by Silvius et al. (1987) and indicated a decline of 30% over the last 20 years. The reduction is likely to be even larger as the 2005 survey covered the area from the coast of Sekinchan to Sungai Bernam which Silvius et al. did not covered. It is believed that loss of habitat due to economic development has contributed to the decline of the bird population.

2.2.1 Factors affecting wader’s distribution and habitat selection

The migration of animals results in seasonal fluctuations in population densities in a particular area. Most wader species migrate along well defined routes called “flyways” and they often use same stopover wintering sites for decades (Kober 2004). During this long migration, which may range from 12,000 km to 25,000 km (Howes and Parish, 1989), birds rely on strategically located stopover sites characterized by a predictable food supply and nearby habitat for resting when foraging sites are tidally inundated (Brown et al. 2001) to replenish their energy and nutrient reserves. The changes in population size during migration are mainly driven by external factors, of which the quality of stopover habitats is one of the most important factor (Ge et al. 2009). During this long distance migration, lower quality stopover sites may result in poor body condition and affect bird’s ability to reach breeding or wintering grounds and reduce adult or juvenile survivorship (Pfister et al. 1998). Thus, Myers (1984 (a)),
suggested that such areas are critical for the continuation of migration and ultimately critical for the survival of many birds.

Site selection is especially important for seasonally migrating animals that show drastic shifts in the habitats they use in the course of annual cycle (Piersma 2012). Selecting an area to live is crucial to all animals, as individuals that occupy sites with greater foraging success and lower predation risk potentially have higher reproductive success and survival, and realize higher fitness (Fretwell and Lucas 1970; Stephens and Krebs 1986; Cresswell 1994; Leyler et al. 2012). Some of factors influencing whether the birds will stops along migration routes are wind, tide, competition, predation and microclimatic condition (Ge et al. 2009). The availability of food in migratory stopover areas has been recognized as being crucial to survival of several bird populations (Burger 1986). Additionally, the dependence of large numbers of waders on just a few sites during migration increases species vulnerability because large numbers of individuals can simultaneously be impacted by changes in habitat suitability and availability (Brown et al. 2001).

2.2.1 Food Resources

Waders migrate between breeding and non-breeding grounds annually, stopping at several coastal bays or estuaries, or inland wetlands during the journey (Morrison 1984). Non-breeding waders generally seek habitat where resource availability is adequate, stable and predictable (Evans and Dugan 1984). Over small spatial scales, habitat selection when foraging strongly influences the composition and diversity of bird assemblages (MacArthur et al. 1966). Besides that, food density has been used by many authors to explain the differential of habitat use by shorebirds at migratory stopover sites (Colwell and Landrum 1993, Isola et al. 2000, Jing et al. 2007).
To maximize fat deposition at stopover sites rapidly, migratory birds feed on whatever is available to them (Recher 1966). Birds may forage for prey that is locally available at any stopover sites (Botto et al. 1998), mainly selecting preys on the basis of their abundance (Davis and Smith 2001). In addition, several studies had shown that foraging success, and hence survival potential of waders can be limited by interference (Triplet et al. 1999, Van Gils and Piersma 2004) or excessive depletion of their prey (Zharikov and Skiletter 2003).

Wader distributions and densities usually match the distribution of their preferred prey species (Zharikov and Skilleter 2004). Most species segregate themselves in the intertidal habitat according to preferences for sediment penetrability and water depth, as birds prefer to feed in shallow water or wet substrates (Lane 1987). Availability of prey is often determined by the maximum depth at which a bird can insert its bill into the substrate and maximum leg length (Dann 1987). This allows a suite of species to co-exist in the same feeding habitat (Dann 1999).

The influence of food resources on the ecology of nonbreeding waders in coastal environments has been well-studied (Burger and Olla 1984; Kober 2004; Finn 2010; Spencer 2010). Zheng et al. (2015), in their study, found that the relative abundance and density of wader, Hooded Cranes, (Grus monacha) were significantly affected by food abundance. Birds interact with prey in two ways, equivalent to functional and numerical responses of predators (Goss-Custard 1977). In the first case, variation in prey abundance may influence foraging behaviour and social interaction of birds, which affects the rate at which prey are consumed additionally, prey abundance may influence spacing of individuals (Goss-Custard 1984; Puttick 1984). Second, variation in prey abundance may affect the distribution of nonbreeding waders within estuaries and among habitats (Evans and Dugan 1984).
2.2.1.2 Environmental Factors

Other than food resources, the abundance and stopover sites selection by waders is also determined by environmental factors such as climate or weather, tidal cycle and salinity of particular habitats. Weather for example can have various biological and ecological impacts on the adults and young birds. Both adults and their nestling were reported to be susceptible to temperature and rainfall particularly during breeding (Sparks and Tryjanowski 2005). Some important examples showed that adults were the first affected by weather during migration and wintering (Saether et al. 2006) and after arrival on the breeding ground (Tryjanowski et al. 2004). Moreover, climate variation in the long term period may influence the animals’ food sources as food availability can be dictated by the weather (White 2008). As in the case of the waders colony in Putrajaya, long term monitoring comprising years of surveys and studies may reveal significant roles of climate in dictating their population size, density, survival and other ecological attributes. This is important for the future conservation of the wader communities (Ismail and Rahman 2013). Similarly, Zduniak (2009), reported that rainy and cold weather conditions have also been reported to cause high chick mortality in young storks and significantly reduce their breeding success and survival. Variation in rainfall and temperatures was also found to have adverse effect on the fledging success of White Stork with poorer food resources (Denac 2006).

Weather was varied with respect to the time of the days. Robbins (1981) said that some bird species decrease their activity during times of extreme temperature (>25 °C). By day, when exposed to direct solar radiation, birds were at risk of heat stress, and only used roost sites with wet substrates or shallow water, where counter-current exchange mechanisms could be used to lower body temperature (Battley et al. 2003). Thermal stress, either because of wind and cold induced rises in maintenance costs
(Wiersma and Piersma 1994) or excessive heat load (Battley et al. 2003), is a function of the geomorphological features of a place, and may also influenced by human disturbance.

Tide is the major factor influencing the distribution, abundance and behaviour of waders (Brennan et al. 1985). Variation in tide level changes the immediate environment (Lehmicke et al. 2013) and thus affects both the amount of foraging space and the availability of prey (Evans 1979, Calle et al. 2016). Burger et al. (1977), found that four of the five species of waders on the mudflat reached peak abundance between 1.5 to 2.5 hours after low tide. Dunlins (Calidris alpina) on extensive tidal flats showed peaks for feeding at 1 hour before and 1 hour after low tide (Ehlert 1964). In contrast, fewest numbers were recorded about 1 hour after high tide. Flooding and ebbing tides alternately inundate and expose intertidal habitats, thus alter the wetness of foraging areas. Foraging waders tend to avoid drier substrates (Prater 1972; Smith 1974; Goss-Custard 1977, Grant 1984) and study by Myers et al. (1980) had demonstrated that substrate texture influences the ability of a bird to penetrate the substrate when probing for prey, which results in birds spending less time in areas of coarse substrate. Furthermore, increased substrate wetness, owing to tidal inundation, probably affects prey availability in two ways; (1) it makes substrates easier to penetrate (Grant 1984) and (2) it increases invertebrate activity, rendering prey more susceptible to wader predators (Goss-Custard 1984).

Manipulation of water levels and salinity may play significant roles in determining habitats that waders can successfully exploit (Velasquez and Hockey 1992). Culmen and tarsus length are positively correlated with water depths in which a species forages, indicating that most birds occur in a specific range of water depths (Baker 1979). The importance of salinity, however, is less clear. Velasquez (1992)
found that birds using artificial saltpans responded to changes in prey composition caused by fluctuations in salinity rather than manipulation of water levels. Burger (1984) speculated that the distributions of species that forage on a narrow range of prey items are more likely to be influenced by salinity than those that have broad prey base.

2.2.1.3 Disturbance and Predation Risk

The distribution of animals is usually thought to be restricted by the occurrence of good feeding areas, with predators and disease organisms determining the quality of such areas in addition to resource abundance (Newton 1998). Stopover sites that combine an abundance of food with a relatively disturbance-free environment allow waders to maximize foraging time and quickly replenish their energy reserve (Helmers 1992). On contrary, sites with extensive anthropogenic and/or natural disturbance may force waders to spend less time foraging (Thomas et al. 2003), while expending more energy in avoiding disturbance, or abandon the sites (Burger 1986; Harrington 1999). Waders are particular in choice of such roosts (Luís et al. 2001), preferring accessible sites. Accessibility is a function of the risk of predator attack, perhaps in combination with human disturbance (Rosa et al. 2006).

Perceived predation risk is thought to underpin the selection of both feeding and roosting sites by waders (Lawler 1996). Waders will select roosts closest to their low tide intertidal feeding habitat and sites which usually have an open aspect allowing easy detection of prey during high tides (Rogers 2003). Most wader species prefer open roost sites which allow the detection of potential predators. Therefore, most waders will avoid areas with tall vegetation (Rogers et al. 2006) such as mangrove, as this vegetation can provide cover for ambushing birds of prey (Dekker and Ydenberg 2004). Several studies have shown that the predation risk of raptors has obvious effects on the habitat
use by birds (Cresswell 1994; Ydenberg et al. 2002). For instance, birds on salt marshes were more likely to be killed by raptors than those on bare flats (open intertidal mudflats) due to difficulties in detecting raptors in vegetated area (Jing et al. 2007).

2.3 Foraging Behaviour of Waders

Waders are a highly mobile group of animals and have sophisticated site-sampling processes that operate at larger spatial scales than most other animals (Quaintenne et al. 2011). Analysis of behaviour can aid in evaluation of wader habitat use and other life history requirement during migration (De Leon and Smith 1999). Behavioural studies should be a method of determining how birds respond to environmental changes and compete for limited resources, such as diminishing habitat (Goss-Custard and Durell 1990). Studied by Rowell-Garvon and Withers (2009), reported that foraging behaviour was the dominant behaviour exhibited by waders and these behaviours seemed to be related to morphological differences among species.

Most of the time spent by a bird during migration is spent at stopover sites (Newton 2008). Habitat requirements for different species and guilds of waders vary in time and space, and this can be detected only by behavioural studies (De Leon and Smith 1999). Documenting behaviour within different types of habitat allows a better understanding of why those habitats are selected (Titman 1981) and provides opportunity to evaluate the significance of regional areas to migratory birds (Streeter et al. 1993; Davis and Smith 1998). Habitat characteristics such as vegetation height and prey abundance could affect foraging behaviour (Holmes and Schultz 1988).

Waders encounter variable and unpredictable food resources (i.e. predominantly invertebrates) at stopover sites (Skagen and Oman 1996; Davis and Smith 1998; Davis
and Smith 2001). In response to those unpredictable food resources, waders should forage opportunistically to successfully complete their migration (Skagen 1997). The term ‘opportunistic foraging’ simply refers to waders consuming prey in proportion to availability (Davis and Smith 2001). However, quality (e.g. gross energy, percentage fat, protein) of available prey items should also be considered when examining migrant waders foraging strategies because nutrient reserves are critical for survival and reproduction (Myers et al. 1979; Maron and Myers 1985). Because waders typically dynamic (Fredrickson and Reid 1990, Farmer and Parent 1997), they likely cannot afford to discriminate between profitable prey and unprofitable prey. Consequently, adopting an opportunistic foraging strategy provide migrant wader with a flexible strategy that allows them to increase their probability of being able to replenish energy and nutrient reserves for continuing their migration to breeding and wintering grounds as well as arriving on the breeding grounds in good conditions (Davis and Smith 1998).

Feeding behaviour and habitat selection in waders is heavily influences by their morphology, particularly leg length and bill length and shape (Baker 1979). The morphology of a bird is considered as an important factor in restricting the range of foraging manoeuvre it can perform (Martin and Karr 1990).

Studies of single-dimensional niche segregation among waders have focused on the relationships between the bill length and prey size (Holmes and Pitelka 1968, Baker and Baker 1973, Eldridge 1987), and between tarsal length and water depth of foraging habitats (Baker 1979; Eldridge 1987). Holmes and Pitelka (1968) reported that bird species with long bills consumed larger prey than did bird species with small bills, and Eldridge (1987) reported that large bird species consumed larger prey and foraged in deeper water than small bird species. Similarly, Schoener (1984) noted that for certain birds, larger species consume a larger range of food sizes than smaller species because
their preferred food (i.e. larger prey) may be relatively scarce and handling costs may be higher. Furthermore, Davis and Smith (2001) found that American Avocets (*Recurvirostra americana*) and Long-billed Dowitchers (*Limnodromus scolopaceaus*) (the larger species) consumed larger prey and foraged in deeper water than did Least sandpiper (*Calidris minutilla*) and Western sandpipers (*Calidris mauri*) (the smaller species).

The foraging methods of even similar species of birds can differ between areas with different vegetation structure (Maurer and Whitmore 1981). However, there are also other ornithologists who claim that the habitat of the bird can be instrumental in influencing other related foraging behaviours such as the height at which it forages and the substrate from which it obtain its prey (Robinson and Holmes 1982). In addition to prey availability, the habitat use of waders may also be constrained by foraging strategies (Kalejta and Hockey 1994; Barbosa and Moreno 1999). Waders detect prey by visual and tactile sensory mechanisms, exhibiting a wide range of feeding styles such as pecking, probing, stabbing, sweeping, ploughing (Ntiamo-Baidu et al. 1998), and surface tension (Rubega 1997). Pecking and probing are thought to be the main methods for visual and tactile foraging respectively (Baker and Baker 1973). For example, medium scolopacids foraged significantly more in habitats that had greater amounts of vegetation, less bare shoreline and deeper water, whereas small charadriids used areas with large expanses of shoreline and shallower water. This difference was due to the larger size and longer legs of medium scolopacids, which allow them to exploit a more diverse array of habitats.

Migrating waders provide an opportunity to study behavioural interactions among species for both prey and foraging spaces because they often forage in dense flocks, concentrating along relative narrow tide lines (de Boer and Longamane 1996).
Foraging birds often form groups to reduce risk of predation while decreasing the cost of vigilance (Bednekoff and Lima 1998). Some species show despotic behaviour such as defense of feeding territories (Turpie 1995; Johnson et al. 2001), while in other species tend to live in flocks (Myers 1984 (b)) when interference is absent or cryptic (Bijleveld and Piersma 2012). As group size increases, scanning rates or vigilance decreases (Roberts 1996). However, some species form groups because of resource location; they forage together because the food is clumped or prey densities are higher in some places than others (Burger et al. 2007). When large group of birds foraged in the same place, competition can result, either for the prey itself or for access to the prey (Stillman et al. 2000). Competition occurs when feeding rate is negatively related to competitor density and when the presence of an individual impedes the access of another individual to a resource (Cresswell et al. 2001). Aggression should occur only when individuals can increase their share of resources that are concentrated by being aggressive (Beauchamp 1998). Increasing spatial clumping of resources, such as prey, can lead to increase competition (Schmidt et al. 1998).

2.4 Threats to Wader’s population

2.4.1 Habitat Losses/ Degradation

The past century has seen massive alteration and loss of natural intertidal habitats that are prime importance to large numbers of migrant waders during the nonbreeding season (Masero and Pérez-Hurtado 2001). Waders face a number of threats to their populations and habitats in the East Asian-Australasian flyway. A total of 20% of wader species that use this flyway are listed as critically endangered or near threatened under IUCN risk criteria (Barter 2002). Waders can be extremely sites faithful (Dan 1981; Rehfisch and Austin 2006), therefore, habitat loss can directly impact their survival and fitness (Burton et al. 2006).
In their non-breeding range, degradation of habitat and excessive disturbance at roost and feeding habitat are thought to be the main threats to migratory wader populations (Smith 1991; Watkins 1993; Department of Environment and Heritage 2005). The loss of habitat through changes in land use practices is the most severe threat to the conservation of water birds (Asia-Pacific Migratory Water bird Conservation Committee 2001).

The intertidal mudflat is one of the most important habitats chosen by wader species during their non-breeding seasons. This area had been shrinking over the past 20 years by continuous reclamation, and some mudflats were almost covered by seawater during high tide, and no super-tidal mudflats remains. Some results of morphological and behaviour research suggested that the birds could not feed and roost at the high water level areas (Zhenming et al. 2006). In such circumstances, a heavy reclamation resulted in the loss of wader’s habitat and forced the waders to move to the neighbouring artificial field inside the seawall such as fishing ponds and paddies field when the tide rose (Hu and Lu 2000; Tang and Lu 2002).

Global climate change projections suggest that sea level rise and prolonged drought (Bates et al. 2008) may reduce the availability of coastal wetlands for migratory waders (Galbraith et al. 2002; Austin and Rehfisch 2003), and the temperature increases may alter invertebrate prey reproduction (Lawrence and Soame 2004) and potentially cause a pole ward shift in the range of many wader species (Chambers et al. 2005).

2.4.2 Disturbance

Increasing levels of human disturbances in estuaries are exerting pressures on wader populations (Hill et al. 1997). Such disturbance includes walking, driving vehicles, or using powered vessels in or near bird flocks. Domestic animals, especially
uncontrolled dogs, can also be a major source of disturbance to waders. Waders are under intense pressure from anthropogenic activities such as land reclamation, habitat destruction, pollution, hunting, and recreation (Tucker and Heath 1994). The general lack of community understanding or education on wader related conservation issues are significant threats to wader survivals.

On their roosting and foraging grounds, waders can suffer high disturbance rates by fishers, watercraft, walkers and dogs (Burger and Gochfeld 1991; Fitzpatrick and Bouchez 1998; Paton et al. 2000; Blumstein et al. 2003) or coastal developments (Burton et al. 2002; Durell et al. 2005). Human-induced disturbance at high tide roost sites (Burton et al. 1996) and low tide feeding sites (Burger 1981; Thomas et al. 2003) can also results in higher energy expenditure and a reduction in food intake for birds at their non-breeding or staging sites (Stillman and Goss-Custard 2002; Coleman et al. 2003), which can impinge on their ability to build fat reserves to fulfil their annual cycle of moult, migration and breeding (Spencer 2010). This has implications for energy conservation as any extra time spent in flight can have significant effects on bird’s body condition and mortality (Durell et al. 2005). Furthermore, high level of disturbance by human activity and avian predators can affect the survival and fitness of birds (Durell et al. 2005; Goss-Custard et al. 2006).

The frequency of disturbance and distance at which waders take flight are often the quantified measures of disturbance (Burger 1981; Blumstein et al. 2003). Human activities can impact on waders more than 200 m away (Thompson 1992). A more subtle measure of disturbance is the level of vigilance and sleep behaviour in roosting individuals. Many bird species sleep with one eye open, so they can respond quickly to perceived threats. Sleep is often accompanied by periods of eye closure interrupted by short periods of eye opening or ‘pecking’ (Landrem 1983; Rattenborg et al. 1999).
Disturbance can cause a reduction in food intake in several ways: the presence of people leads to increased vigilance by foraging waders and to a decrease in the proportion of time devoted to feeding (Burger and Gochfeld 1991), the birds may stop foraging altogether and they may leave the foraging site (Smit and Visser 1993), perhaps changing to a less profitable site at which they have a lower food intake rate (Burger 1988). In addition to this reduction in food intake, energy expenditure can be increased by avoidance behaviour, particularly if the birds fly away. The combination of these effects may produce serious deficits in the daily energy budget of the disturbed birds (Bélanger and Bédard 1990), or necessitate extra compensatory foraging, for example, at night (Riddington et al. 1996). There would be variation between individuals in the effect of disturbance according to their age, feeding method and dominance (Goss-Custard and Durell 1988). Depending on the proximity and type of human activity (walking, fishing, etc), waders may respond either by spending more time watching potential human threat, or by walking away from approaching humans (Fitzpatrick and Bounchez 1998), or by taking flight and moving to a nearby undisturbed section of beach (Smit and Visser 1993). Although these types of reactions have some effect on waders, particularly a reduction in foraging time, a potentially more serious consequence of human and dog activity would be the abandonment of a valuable foraging area by some or all waders. It is generally agreed that disturbance, especially that caused by recreational activities, is a threat to waders, since many recreational activities may increase in intensity and distribution (Cayford 1993).
2.5 The Significance of Study

Effective wader conservation is dependent on a detailed understanding of the distribution of wader populations, their life history and habitat requirements (Spencer 2010). Many studies on waders in Malaysia was focussed on wader’s distribution and abundance (Parish and Wells 1984, 1985; Edwards et al. 1986; Hawkins and Howes 1986; Howes et al. 1986, Li et al. 2007; Riak 2004; Lomoljo 2011) only. This study focussed on to improve the data on wader’s population in two sampling sites, which are Jeram Beach and Remis Beach which were previously known as important stopover sited for migratory waders.

Some of the species found in this study were listed as Vulnerable in which if no further action were taken might cause these species were at risk of becoming endangered. For this reasons, the knowledge on abundance and distribution of waders alone is not enough for the conservation efforts of these species to be carried out effectively. Thus, this study focussed on investigating the factors which affecting the distribution, abundance and behaviour of wader species utilizing non-breeding stopover sites such as tide, time of the day, morphological characteristics and disturbance. Therefore, this study also provided new detail information on factor affecting the distribution, abundance and behaviour of waders in Malaysia. This information can be used for more effective conservation of waders in Malaysia. For example, in this study, species of waders which were found to be the most sensitive towards disturbance can be used to set the barrier or buffer zones for mixed-groups of waders at foraging and loafing sites.