# Asiatic Soft-shell Turtle *Amyda cartilaginea* in Indonesia: A Review of its Natural History and Harvest

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**Abstrak**

Makalah ini mengulas tentang biologi dan pemanenan labi-labi *Amyda cartilaginea* di Indonesia. *A. cartilaginea* tersebar secara luas di Indonesia, terutama pada lahan basah di pulau-pulau besar. Dari berbagai survey diketahui bahwa *A. cartilaginea* ditemukan pada berbagai habitat perairan tawar, sebagian bahkan dapat ditemukan di sekitar permukiman. Individu betina dapat bertelur beberapa kali dalam setahun, namun masa biak tidak dapat ditentukan dengan pasti. Labi-labi betina diperkirakan mulai mampu bereproduksi sekitar usia 3 tahun. Meski pun labi-labi tidak pernah ditemukan dalam jumlah banyak pada suatu wilayah karena warnanya yang tersamar, jumlah populasinya secara umum melimpah. Mengingat bahwa spesies ini telah terdaftar dalam CITES Appendiks II, maka pemanenan labi-labi *A. cartilaginea* untuk tujuan ekspor telah diatur oleh pemerintah Indonesia. Pemanenan labi-labi dilakukan sepanjang tahun, tanpa memperhatikan jenis kelamin. Penelitian lebih mendalam tentang ekologi labi-labi dan dampak pemanenannya masih diperlukan. Pemanenan labi-labi dianggap mengkhawatirkan bagi kelestarian spesies ini. Untuk pengelolaan spesies, pemantauan tahunan terhadap pemanenan dengan menggunakan metoda standard perlu dilakukan, khususnya pada lokasi dengan jumlah pemanenan yang tinggi.

**Abstract**

This paper provides a review of the natural history and harvest levels of the Asiatic soft-shell turtle *Amyda cartilaginea* in Indonesia. *A. cartilaginea* is distributed widely in Indonesia, mostly in wetlands of the major islands. Surveys have found that *A. cartilaginea* reside in various freshwater habitats, even some near the vicinity of human settlements. There is no apparent breeding season, and females might lay more than one clutch during the year. It is estimated that females become reproductive around 3 years of age. Although *A. cartilaginea* is never seen in large numbers in one area, mostly due to its cryptic nature, it is generally considered abundant. Harvest of *A. cartilaginea* for export is regulated by the Government of Indonesia, as part of its inclusion in Appendix II of CITES. In practice, harvest is conducted all year, with no apparent preference for sex, but more research is needed regarding the species ecology and impact of harvest. The harvest of *A. cartilaginea* in Indonesia is a major concern for the conservation of the species. Annual monitoring of harvest levels using standardized methods should be carried out especially in locations subjected to high harvesting pressure, to assist management of the species.

*Keywords*: *Amyda cartilaginea*, harvest, trade, population

## Introduction

The Asiatic soft-shell turtle, *Amyda cartilaginea*, is distributed in Southeast Asia from Myanmar to Indonesia. It is one of the largest fresh-water turtle species in Indonesia with a carapace length reaching up to 80 cm (Iskandar, 2000). The turtles occupy a wide range of habitats, such as muddy rivers, ponds and irrigation canals, slow moving lowland streams and rivers, swamps, and oxbow lakes adjacent to large rivers (Lim & Das, 1999). In Indonesia, the species is found almost in all big islands, such as Borneo, Sumatra, Java, Bali and Sulawesi except for Papua (Auliya, 2000; Iskandar, 2000; Koch et al., 2008).

*A. cartilaginea* is exploited for consumption in Indonesia (Asian Turtle Trade Working Group, 2000; Iskandar, 2000) and due to years of extensive harvesting the population has declined in all range countries except Brunei Darussalam, Cambodia and India (CITES, 2004). The species is now listed as "Vulnerable" on the IUCN Red-list, mostly due to habitat loss and

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over-exploitation (Asian Turtle Trade Working Group, 2000). As the only country with a quota for export, Indonesia is under scrutiny for its extensive legal hunting of *A. cartilaginea*. According to data by the WCMC database, the harvest quota for individuals of this species was 25,200 heads in 2013. At the inclusion of this species in CITES as Appendix II, exports of live turtles in Indonesia exceeded quota levels (2005 to 2007), whereas after 2008 the export never exceeded the legal quota (Tab.1). Despite the large off-take of this species, information pertaining to harvesting effort, demography, ecology or conservation of the species in Indonesia is lacking. From 2009 to 2012, a series of research activities on *A. cartilaginea* were conducted in various locations in Indonesia, consisting of harvest monitoring in Kalimantan and Sumatra, and breeding biology in experimental breeding farms. This paper aims to compile available knowledge about a) ecology and life history, b) population dynamics, and c) review the existing information about harvest and trade of *A. cartilaginea* in Indonesia.

## Ecology and life history

The Asian soft-shell turtle, *Amyda cartilaginea*, is a big sized freshwater turtle. The maximum carapace length (CL) of *A. cartilaginea* has been reported to reach 100 cm, although the CL of most *A. cartilaginea* found in the wild measure up to 60 cm (Iskandar, 2000). The longest carapace length reported, based on survey data, is 80 cm in East Kalimantan (Kusrini et al., 2009) and 70 cm in Riau (Mumpuni and Riyanto, 2010). In East Kalimantan, turtles harvested for trade typically weigh 13.5 kg (n = 612) but have been recorded up to 65 kg (Kusrini et al., 2009). There is no literature available on growth rates.

There are no records on *A. cartilaginea* longevity, age at first reproduction or maximum breeding age. However, Mumpuni and Riyanto (2010) reported that the CL of a 2 year old mature female measure approximately 30 cm. Using data from East Kalimantan (Kusrini et al., 2009), a 30 cm CL corresponds to a 3 kg body mass for *A. cartilaginea*. Results from dissections of female turtles collected in Jambi Province (Sumatra) showed that the smallest size of sexually mature females measured 28.5 cm CL, 24 cm Carapace Width (CW) and 2.2 kg body mass (Mumpuni & Riyanto, 2010). Ginting (2012) reported that the smallest sexually matured female turtle dissected with egg follicles measured 32.4 cm CL and 3.19 kg body mass. Therefore, it is reasonable to assume that a 2 year old female is already able to reproduce.

Reports on the number of eggs per clutch varied. Iskandar (2000) indicates 40 as the maximum clutch size, whereas Liat and Das (1999) stated that the clutch sizes range from 5 – 30 eggs. Hunters in East Kalimantan reported that the number of eggs per clutch was 20-50 (Kusrini et al., 2009). From nine nests occurring at Belawa Villages (West Java), the number of eggs found was 3 – 17 per nest (Kusrini et al., 2007). Susanti (2013) reported that the number of eggs from 10 nests at an experimental farm was 11 – 19 eggs per clutch. Based on dissection of 6 specimens, Mumpuni and Riyanto (2010) found the number of follicles ranged from 16 – 29 with at least two different sizes, which suggest that the species might be able to release eggs at least twice during breeding season.

New eggs are usually pure white in color, translucent (somewhat transparent) and the outer skin of the egg is soft. Eggs that have been long in the nest are a white or creamy white bone colour (not shiny), smooth, and hard-shelled, but fragile (Kusrini et al., 2007). The size of *A. cartilaginea* eggs is shown in Table 2.

Incubation time differs for each clutch, which reflects environmental variables such as nest temperature and humidity, as is the case for other turtle species. Iskandar (2000) reported that eggs of *A. cartilaginea* hatch after 135-140 days, whereas Susanti (2013) reported

**Table 1.** Exports and quotas of *Amyda cartilaginea* from 2005 – 2013 (Source: WCMC, CITES Trade Database*, Directorate General of Forest Protection and Nature Conservation).

| Year | Export Quota | Actual Exports* | Purpose |
|---|---|---|---|
| 2005 | 27000 | 34066 | Consumption |
| 2006 | 27000 | 32665 | Consumption |
| 2007 | 27000 | 26710 | Consumption |
| 2008 | 25200 | 25197 | Consumption |
| 2009 | 25200 | 25200 | Consumption |
| 2010 | 25200 | 25104 | Consumption |
| 2011 | 23400 | 24764 | Consumption |
| | 1800 | | Pet |
| 2012 | 25200 | No data | Consumption |
| 2013 | 25200 | No data | Consumption |

| Source | Mean | | Range | |
|---|---|---|---|---|
| | Diameter (mm) | Weight (g) | Diameter (mm) | Weight (g) |
| Pritchard (1979) | - | - | 30.5 – 35.5 | - |
| Liatt & Das (1999) | - | - | 21.0 – 40.0 | - |
| Kusdinar et al. (1999) | 32.3 | 17.2 | 31.1 – 33.2 | 14.5 – 18.8 |
| Iskandar (2000) | - | - | 21.0 – 33.0 | - |
| Kusrini et al (2007) | 30.0 | 17.6 | 27.0 – 32.0 | 13.9 – 21.4 |
| Susanti (2013) | 31.8 | 19.5 | 28.4 – 34.6 | 12.0 – 24.0 |

**Table 2.** Diameter and weight of *Amyda cartilaginea* eggs.

| Age group | Approximate age (year) | # of dead individuals |
|---|---|---|
| Un-reproductive adults | > 80 | 7 |
| Reproductive adults | 3-20 | 80 |
| Juveniles | 0-1 | 125 |
| | **Total** | **212** |

**Table 3**. *Amyda cartilagenea* mortality in Belawa Village Cirebon during the infection episode in 2010 (Source: Sunyoto 2013).

**Table 4**. Habitat characteristics of *Amyda cartilagenea* at different locations in Indonesia.

| Location | Habitat type | Adjacent landscape | Water body width | Depth (m) | Vegetation around water bodies | Source |
|---|---|---|---|---|---|---|
| Bulungan, Berau, and Malinau Regencies at the northern part of East Kalimantan Province | River | Rural and ex logging concession area | 5-20m | 3-8 | Hard wood and bushes, mostly unshaded | Kusrini et al 2009 |
| Sambas and Ketapang Regency, West Kalimantan | River | Not available | Not available | Not available | Not available | Lily 2010 |
| Ogan Komering Ilir Regency, South Sumatra | River, swamp and flood plain | | 25m (river) 1200ha (fresh-water swamp) | 2-7 | Grass and bushes, Mostly unshaded | Oktaviani 2007 |
| Rokan Hulu and Siak Regency of Riau Province, Sumatra | River and peat swamp | Palm oil plantation | 2-5m (river) 5-7ha (peat swamp) | 1.5-2 | Grass and bushes, mostly unshaded | Mumpuni & Riyanto 2010 |
| West Sumatra | Irrigation channel, river | Rice fields, human habituation | 0.5 – 2m (water irrigation) | 0.3-1.2 | Paddy, grass, garden plants, mostly unshaded | Mumpuni et al. 2011 |
| Belawa Village, Cirebon Regency of West Java Province | Man-made fish pond | Human habituation | 0.01-0.2ha | 1.5-3 | Few garden plants, mostly unshaded | Kusrini et al. 2007 |


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that from three clutches of eggs induced by artificial incubation, juveniles emerged after 95 - 102 days of incubation. Newly hatched juveniles live primarily on their egg yolk for 3-5 days after hatching. The size of newly hatched juveniles range from 4.0 – 5.1 cm CL with a body weight of 9.0 – 17.0 g (Susanti, 2013).

In Riau, Mumpuni and Riyanto (2010) reported that the diet of *A. cartilaginea* consisted of oil palm seeds, cassava, scrap, fish, unidentified leaf and seeds and avifauna. Furthermore, Mumpuni et al. (2011) indicated that the soft-shelled turtle at Bandar Gadang (West Sumatra Province) in rice fields consumed primarily snails of the species *Pomacea canaliculata*, similar to the finding of Ginting (2012) in Jambi, suggesting that *A. cartilaginea* is an important predator of this pest. In Belawa (West Java) the turtles are sometimes given food by villagers consisting of water spinach, dried fish, and other food scraps (Kusrini et al., 2007). All of this is relevant to the conclusions of previous researchers that *A. cartilaginea* is an opportunistic omnivore (Amri & Khairuman, 2002; Iskandar, 2002; Jensen & Das, 2006; Pritchard, 1979).

Information on the diseases of *A. cartilaginea* is scarce. In 2010, Indonesian media reported that hundreds of *A. cartilaginea* died in Belawa, West Java (Haryadi & Pamungkas, 2010). An unpublished report by the fisheries quarantine laboratories in Cirebon revealed that these turtles were infected by *Saprolegnia sp*. fungus, along with *Edwardsiella tarda* and *Aeromonas veronii* bacteria (Badan Karantina Ikan Pengendalian Mutu dan Keamanan Hasil Perikanan, undated). Sunyoto (2010) reported that more than 200 turtles died from the infection in a very short time (Tab. 3).

A report by Indonesia CITES MA (2008) cited information by traders in Kalimantan and Sumatra that many *A. cartilaginea* were infested by leeches. Information by Sudiana et al. (2000) in Java showed that 90% of the samples of wild *A. cartilaginea* were infested by the ectoparasite worm, *Pseudocalceostoma sp*. both on the carapace and plastron.

There has been little information on micro-habitat use and movement of the *A. cartilaginea*. Kusrini et al. (2009) reported that hunters in East Kalimantan find *A. cartilaginea* in underground cavities of riverbanks, where they rest, mate, and congregate. Furthermore, hunters reported that 7 to 12 *A. cartilaginea* can use the same mud cavity at the same time.

*A. cartilaginea* is primarily aquatic but, as with most turtles, females lay eggs in terrestrial nests near water bodies. Almost all reports stated that key habitats consist of a variety of freshwater habitats: ponds, lakes (including oxbow lakes adjacent to large rivers), streams and rivers (upland streams and muddy, slow-flowing lowland streams, and rivers), peat swamps, canals, and possibly estuaries (Auliya, 2007; Iskandar, 2000). Surveys in the last few years in Kalimantan, Sumatra and Java shows that key habitat is not necessarily situated in natural areas with dense vegetation surrounding the water bodies (Ginting, 2012; Kusrini et al., 2009; Lilly, 2010; Mumpuni & Riyanto, 2010; Mumpuni et al., 2011; Oktaviani, 2008). Instead, *A. cartilaginea* is well adapted to water bodies near human habitation or man-made habitats such as fish ponds and water channels adjacent to paddy fields (Tab. 4). This might explain its wide distribution.

Nesting usually take place near water bodies. In East Kalimantan, hunters reported that *A. cartilaginea* lays eggs underground in muddy substrate or among tree buttresses covered with leaves and rotten wood (Kusrini et al., 2009). Surveys by Mumpuni et al. (2011) in West Sumatra found a nest containing 6 eggs near an irrigation channel for rice fields, beneath a kapok tree (*Ceiba pentandra*). In Belawa, Cirebon (West Java), nests were found on sloping ground at the edge of the pond, covered by grass, with the distance to the water of about 1.9-4.5 m (Kusrini et al., 2007).

## Population estimates

Previous reports categorized the population of *A. cartilaginea* in Indonesia as "common" or "locally abundant" (Samedi & Iskandar 2000). In contrast, a report by Setyobudiandi and Zairion (1997) mentioned difficulties in finding the species in West Java, which resulted in *A. cartilaginea* in Java being considered "not suitable for commercial harvest". However, to date there exists no reliable population estimate with the current estimates subjected to various biases. For example, in Belawa Cirebon, the local people often reported that the present harvesting numbers of *A. cartilaginea* were lower compared to past harvesting numbers. While it may provide a relative indication of population size, it may also merely reflect changes in harvesting efforts. In 1995, Kusdinar et al. (1999) found 88 individual turtles in Cikuya River in Belawa (consisting of 6 hatchlings, 12 juveniles and 70 mature individuals). This is approximately half of what was found in a 2007 survey (Kusrini et al., 2007) where 161 individuals were recorded. Low sightings and capture

rates do not necessarily mean low population size but can be a result of sampling bias as experienced in many other herpetological surveys (Plummer et al., 2008; Wilson et al., 2008), especially for cryptic species. Since *A. cartilaginea* tends to stay covered in mud for prolonged periods of time (Sunyoto, 2012) they are particularly subject to estimation bias.

Efforts to estimate populations were carried out in East Kalimantan (Kusrini et al., 2009) and Sumatra (Mumpuni et al., 2010, 2011). Using a series of baited hooks for two weeks, 36 individual *A. cartilaginea* were captured collectively in East Kalimantan (Kusrini et al., 2009). A rough estimate revealed a relative density of 0.66 *A. cartilaginea per* kilometer of river in East Kalimantan. A higher value was provided by Mumpuni et al. (2011) in their survey in West Sumatra, where the relative density of *A. cartilaginea* in water irrigation channels reached 16 individuals/km. In Lubuk Dalam peat swamp in Riau, in the vicinity of an oil palm plantation, the relative density of *A. cartilaginea* was 21 individuals/ha (Mumpuni et al., 2010). These results indicate that the density of the soft-shelled turtles varied according to location. However, there might be bias in calculating density due to (1) observer variation, (2) unequal capture effort and difficulties, (3) inclusion of escaped captured turtles, and (4) movement and migration of turtle. Surveys showed that the soft-shelled turtle tend to be solitary, able to be submerged in water for long periods of time, thus visually difficult to detect and most probably has a wide home range. Irrespective of natural densities or habitat types, tens of thousands of turtles are captured and traded every year (Tab. 1).

## Harvest and trade

Harvesting techniques varied according to location. In East Kalimantan Kusrini et al. (2009) reported that hunters harvest turtles using baited hooks, except in Sebuku, where respondents used long sticks to locate turtles. To fish for turtles, a series of 10 – 70 baited hooks are placed at certain distances along a riverbank. Bait consists of meat from a variety of species such as chicken, fish, wild boar (*Sus scrofa*), monitor lizard (*Varanus salvator*), reticulated python (*Python reticulatus*), and even primates e.g. Proboscis monkey (*Nasalis larvatus*). Fishing lines with hooks are usually placed during high water and checked at least three times, each with an hour interval, before the hunter moves to another hunting site(s). If a turtle takes the bait, the hunters remove it and transports them to a collector alive. The use of baited hooks was also reported by Walter (2000) in Sentarum Lake, West Kalimantan.

In West Sumatra, harvesting is carried out by pole fishing and a blunt stick (Mumpuni et al., 2011). The first method is usually applied by fishermen mainly to catch fish, with turtles not the main target and being a by-catch. The second method is used by professional turtle hunters. A team consisting of 3 to 5 people will walk along small creeks or tunnels to search turtle using a blunt stick to probe the bottom. Whenever the tip of the stick strikes a turtle, the hunters will surround and catch it. The method is usually applied during dry season between February and June. In Air Hitam Dalam River in Sumatra, professional turtle hunters used fishing rods to capture *A. cartilaginea* as well as rattan funnel traps using duck-meat as bait. The fishing rod was checked every day in the afternoon. In Riau and Jambi, nylon funnel traps known as *lukah* measuring 100 cm x 80 cm x 100 cm and metal funnel traps (*pengilar*), measruing 80 cm long and 40 cm in diameter were also used, as well as electric fishing methods (Mumpuni & Riyanto, 2010).

In general, hunters do not differentiate between males and females of *A. cartilaginea* in Indonesia, which is illustrated by the equal proportion of females and males captured (Kusrini et al., 2009; Lilly, 2010; Ginting, 2012). Instead, the sex ratio of the harvested specimens of *A. cartilaginea* seemed to illustrate the success of capture effort. We assumed that these conditions were primarily caused by the nature of harvesting, which occurs all year round, excluding the possibility of catching only one specific sex (e.g. if only hunting in the nesting season). In addition, there are no specific consumer preference for neither males nor females. This is of critical conservation importance, because preference for particularly breeding females can have several negative consequences. A high proportion of female Pig-nosed turtle (*Carettochelys insculpta*) is harvested in Papua New Guinea, which are typically captured during the nesting seaon (Eisemberg, 2010), and similarly for the Mekong snail-eating turtle (*Malayemys subtrijuga*) in Cambodia, because of comsumer demand for females with eggs as special dishes (Platt et al., 2008).

Harvest size-limits are imposed by Indonesia's CITES Management Authority, and are based on weight. By these rules hunters are allowed to harvest specimens weighing less than 5.5 kg (mostly for pets) or more than 13.5 kg (for meat/consumption), leaving most of


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the reproductive individuals (Indonesia CITES MA, 2008). Unfortunately, in practice all measurements of the harvested turtles reveal that more than half fell within the prohibited range of 5.5-13.5 kg. Based on surveys carried out in Kalimantan (Kusrini et al., 2009; Lily, 2010), and Sumatra (Ginting, 2012; Mumpuni et al., 2011; Oktaviani, 2007), the population structure, based on the body weight, showed a heavy bias towards small individuals, with the smaller turtles captured at a much higher rate than larger reproductive individuals.

The fact that harvests mostly captured small size turtles probably corresponds with the size structure of actual populations in the wild. Assuming that the demography of *A. cartilaginea* in Belawa represented the wild population elsewhere, results of Kusrini et al. (2009) surveys showed that the population of *A. cartilaginea* scattered in ponds in Belawa consisted mostly of small individuals. Of the 161 turtles found, 3.7% were hatchling, 50.9% were juvenile, 33.6% were sub-adult and only 11.8% were adult.

In 2009, 18 exporters established the association APEKLI (Asosiasi Pengusaha Kura-kura dan Labi-labi Konsumsi Indonesia; Association of Turtle and Soft-shelled Turtle Traders). Quota levels for turtle harvest set by Indonesia CITES MA were disseminated to the members of the Association. Export quotas for *A. cartilaginea* is based on heads, and not by weight. Since the price of *A. cartilaginea* for consumption depends on weight, traders prefer to sell bigger sized turtles, rather than smaller sized. All exporters get turtles from their collectors, and although exporters might decide to refuse turtles when quota limits are passed (Indonesia CITES MA, 2008), in reality traders claim that rejecting harvesters is not possible due to social concerns (Maraden Purba, pers. comm). Small turtles are sometimes kept in holding ponds until they grow to sufficient sizes (Ginting, 2012; Indonesia CITES MA, 2008; Oktaviani, 2007) or they are sold for domestic and international markets beyond the quota limits. At the moment, there is no information on the estimated number of turtles used for domestic consumption.

The export quota for *A. cartilaginea* remained stable at 27,000 heads between 2005 and 2007. In 2008, the export quota for *A. cartilaginea* was adjusted

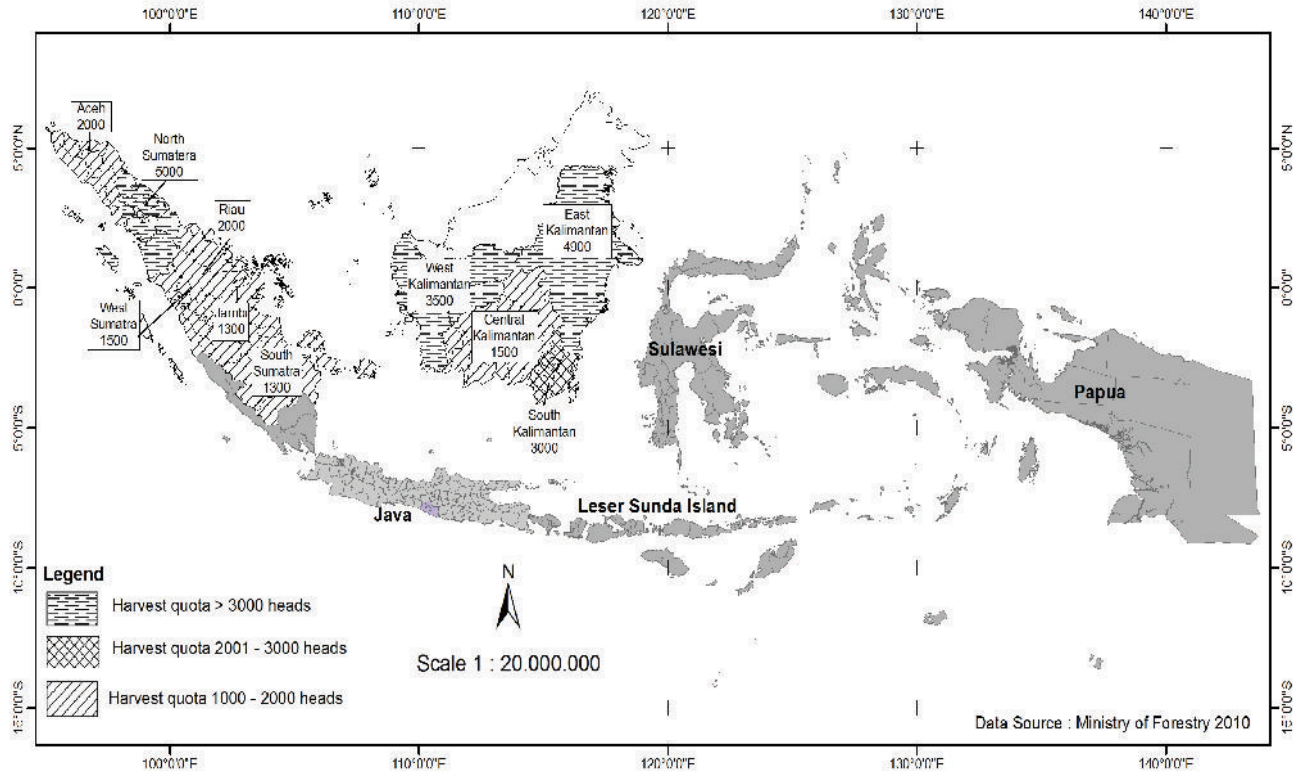


**Figure 1.** The distribution of 2010 harvest of *Amyda cartilagenea* from Indonesia (Data Source: Directorate General of Forest Protection and Nature Conservation).

downwards to 25,200. The quota covers two purposes, namely for consumption and for pets, in which more than 80% are for consumption (Tab. 4). Based on 2005-2012 CITES trade data, *A. cartilaginea* from Indonesia is exported to 22 countries from Asia, Europe, North America and Middle East, with the majority going to Singapore (49%), Hong Kong (36%) and China (9%). Except for the Netherlands, that still imports of small numbers of *A. cartilaginea* in 2010 and 2011, export of Indonesian *A. cartilaginea* to Europe stopped after a European Union Wildlife Trade Regulation suspended *A. cartilaginea* from Indonesia in 2008.

Based on data published annually by Indonesia CITES MA, the source of *A. cartilaginea* came from two main islands of Indonesia: Kalimantan and Sumatra. Using the 2010 harvest data, two provinces have the highest production of *A. cartilaginea* namely East Kalimantan and North Sumatra Province (Fig. 1).

The high number of reproductively active *A. cartilaginea* captured each year has raised concerns about maintaining a stable population in the wild. The available data on the relative density of the *A. cartilaginea* from previous surveys might be useful to gain insight into the number of harvestable specimens within a province. The risk of this, however, is that such data may provide an inaccurate estimation of *A. cartilaginea* population in a province and, therefore, a false foundation for quota setting. Whereas key habitat of *A. cartilaginea* consists mainly of fresh water wetlands, possibly shallow freshwater wetlands located below 500 m above sea levels (Oktaviani, 2007) there is no available data on size of freshwater wetlands in each province in Indonesia. It is estimated that there are more than 20 million ha of freshwater habitat in Indonesia, excluding rivers (Komite Nasional Pengelolaan Lahan Basah Indonesia, 2004). Considering the availability of a wide range of key habitats for *A. cartilaginea*, it is estimated that the potential number of harvestable turtles is in fact higher than the existing quota. Estimations of harvest levels in East Kalimantan indicate that the capture rate was still far below the production of *A. cartilaginea* in the survey area. However, without accurate data on national or international trade, or turtle populations, a precautionary approach should be used in harvesting regimes.

The export harvest for two companies in Balikpapan in 2008 was 3,979 heads which included 13% mortality (ID CITES MA, 2008). Currently, there are no *A. cartilaginea* breeding farms in Indonesia, however, breeding trials are already underway in several locations. In Siak Regency, Riau (Sumatra), the pulp and paper company of Sinar Mas Group has prepared a facility to breed *A. cartilaginea*, and started with a holding of 48 parent stock (Mumpuni et al., 2010). Unfortunately, there have been no further reports on the development or success of this facility over the past several years. The association of turtle traders has begun to encourage members to carry out breeding trials in Tangerang (Banten Province), and nine parent stock (6 females and 3 males) kept in a pond by PT Ekanindya Karsa since 2008 successfully breed at the end of 2011 (Susanti, 2013). The company, whose main commodity is captive breeding of crocodiles, has expanded with ponds designed to house the new juvenile *A. cartilaginea*.

## Conservation recommendations

It is clear from the limited available data that there is a need for more information to assess the impact of harvesting on the populations of *A. cartilaginea* in site specific regions. Further research on reproduction, ecology and population dynamics should be undertaken at localities across the range of *A. cartilaginea* for comparative purposes. Long term research should be initiated in areas where the *A. cartilaginea* is abundant, in harvested and non-harvested areas. Standard methods to monitor *A. cartilaginea* population should be developed, including methods to mark individual for the purpose of mark-recapture studies. Modeling of habitat suitability of *A. cartilaginea* should be carried out.

Trade monitoring should be done monthly and be reported annually by the respective Regional Forestry Office in each province (BKSDA). To assess population structure and seasonal fluctuation, exporters should provide a record of size/weight collected by harvesters. Trade monitoring should also include monitoring of *A. cartilaginea* for domestic consumption.

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