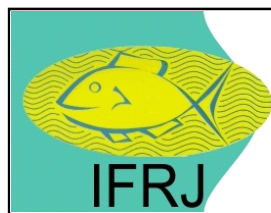


*Biodiversity and Habitat Preferences.....in The Southeast Asian Region (Ali, A., et al)*



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## **BIODIVERSITY AND HABITAT PREFERENCES OF LIVING SHARKS IN THE SOUTHEAST ASIAN REGION**

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### **ABSTRACT**

This paper reviews the biodiversity and habitat preferences of living sharks in the Southeast Asian region accumulated from published literatures including journals, books, proceedings, unpublished technical papers, and technical reports as well as authors' knowledge and experiences working in this field. A total of 196 species of sharks from nine orders and 30 families have been recorded inhabiting from fresh water to deep ocean in this region. Indonesia recorded the highest diversity with 114 species from 27 families followed by the Philippines with 96 species (27 families), Thailand 76 species (21 families), Vietnam 70 species (23 families), Malaysia 68 species (19 families), Myanmar 64 species (19 families), Brunei Darussalam 45 species (15 families), and Cambodia with 26 species from 10 families. Many species still need to be confirmed and are most probably new species. In term of habitat preferences, 83 species of sharks (42.3%) inhabit continental/insular shelves (SHL) followed by continental/insular slopes (SLO) with 48 species (24.5%), shelf to slope (SHS) with 26 species (13.3%), and shelf to oceanic (SHO) with 16 species (8.2%). Only nine species (4.6%) inhabit oceanic and six species (4%) obligate freshwater and euryhaline freshwater/shelves.

**Keywords: Sharks; biodiversity; habitat preference**

### **INTRODUCTION**

The sharks, rays, skates, and chimaeras, collectively known as the Chondrichthyes or cartilaginous fishes, are belong to one of the two major taxonomic groups of modern fishes. Ebert *et al.* (2013), listed more than 500 valid species of living sharks in the world. Weigmann (2016), in his reviewed on biogeographical diversity of Chondrichthyans listed nine orders, 34 families, 105 genera and 509 species of living sharks. Within the Southeast Asian region, shark is one of the major contributors to the rich biodiversity in the region. According to Compagno (2002), the South China Sea and adjacent areas have a rich shark fauna with at least 136 species. Several look-alike species were also recorded during surveys conducted since 1990's such as reported by Arshad *et al.* (2017), Krajangdara (2017), Robert *et al.* (2015), and others.

According to Compagno (2002) and Last & Compagno (2002), habitat occupied by sharks are

divided into three categories: marine continental and insular shelves (from freshwater lakes and river to 200 m depth; continental and insular slopes below 200 m and extending to 2000 m depth; and oceanic realm beyond the continental shelves and above the slopes and ocean floor. For this region, many species overlap two or more of these categories and can be placed in shelf to slope (SHS), slope to oceanic (SOC), shelf to oceanic (SHO), shelf to semi-oceanic (SSO), and wide range of habitats (WRH). Other habitats are euryhaline fresh water/shelves (SHF) for instance species of Bull shark (*Carcharhinus leucas*) occurring near the bottom to depths of 150 m (Compagno, 2001), confined in oceanic (OCE), continental/insular shelves (SHL), and continental/insular slopes (SLO). Compagno & Cook (1995) placed freshwater elasmobranch for those species confined in fresh water as obligate freshwater (FWO).

Knowing diversity of sharks and rays in the Southeast Asian region is essential for shark and ray fisheries management. Data of the occurrence, habitat,

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and distribution of certain species are used as basic information prior determining their management strategies. The stock population of some widespread species might be shared among countries in the region. Therefore, their fisheries should be considered to be managed at regional level, and not under particular country. However, accurate information on biodiversity of shark and ray species in Southeast Asian region is still limited. This paper aims to present an update reviews on the biodiversity and habitat preferences of living sharks in the Southeast Asian region.

## MATERIALS AND METHODS

This paper is based on field and lab works by the authors in the region from 1999 to 2018. It is also based on the accumulated information from published literatures that include journals, books, proceedings, unpublished technical papers, and technical reports on research on taxonomy of elasmobranch in all countries. The main sources for this paper are from Monkolprasit (1984), Compagno (2002), Last & Compagno (2002), Vidthayanon (2002), Yano *et al.* (2005), White *et al.* (2006), Fahmi (2010), Last *et al.* (2010a), Last *et al.* (2010b), Ali *et al.* (2013), Ebert *et al.* (2013), Robert *et al.* (2015), Weigmann (2016), Krajangdara (2017), and Fahmi & Ebert (2017).

## RESULTS AND DISCUSSION

### Results

Information on biodiversity of sharks and rays are vary across the Southeast Asian region. In general, data collections and shark and ray studies are limited in many countries in the region such as in Brunei Darussalam, Myanmar, Cambodia, and Vietnam. Only few countries have historical data and more comprehensive studies on this group of fishes. Brunei Darussalam has very limited information on biodiversity of sharks.. The most comprehensive study on the biodiversity of elasmobranchs in Brunei Darussalam was conducted in 1999-2004 that recorded 34 species of sharks from 13 families (Yano *et al.*, 2005). A study conducted in Cambodia from 2003 to 2004 sponsored by the Southeast Asian Fisheries Development Center (SEAFDEC) recorded 45 species of sharks from two landing sites (Sereywath, 2006). Vidthayanon (2008), in his study within Mekong Delta, recorded four species of sharks only among 360 species of freshwater, estuarine and marine fishes in Cambodia.

Studies on elasmobranch and teleost taxonomy have been conducted in Indonesia since early 19<sup>th</sup> century. It was started near Waigeo Island by European

explorer from 1818 to 1826, where the blacktip reef shark, *Carcharhinus melanopterus*, was originally described from this Island (White *et al.* 2006; Fahmi, 2010). The first research on the taxonomy of sharks and rays in Indonesia had been carried out from 2001 to 2006. This collaborative work between Australia and Indonesia recorded 137 chondrichthyans species consisting 78 species of sharks, 56 rays, and three chimaeras (White *et al.* 2006). In the latest study and review conducted by Fahmi (2010), a total of 213 species from 41 families, comprising 112 sharks and 98 rays, were recorded. A deep-sea collaborative research between OFCF-Japan and AMFR-Indonesia from 2004 to 2005 also contributed to the additional number of deep-sea sharks in Indonesian waters. This project reported at least 15 species of deep-water sharks occur in the Indian Ocean (Anonymous, 2006). Since 2005, many new species have been described from Indonesian waters such as *Atelomycterus baliensis* (Bali catshark; White *et al.*, 2009), *Mustelus widodoi* (Whitfin smoothhound; White & Last, 2006), *Squalus hemipinnis* (Indonesian shortnose spurdog; White *et al.*, 2007), *Halaelurus maculosus* (Indonesian speckled carpetshark; White *et al.*, 2007), *Squatina legnota* (Indonesian angelshark; Last & White, 2008), *Hemiscyllium galei* (Gale's epaulette shark; Allen & Erdmann, 2008), *Hemiscyllium henryi* (West Papuan epaulette shark; Allen & Erdmann, 2007), *Hemitriakis indroyonoi* (Indonesian houndshark; White *et al.*, 2009), *Cephaloscyllium pictum* (Painted swellshark; Last *et al.*, 2008), *Orectolobus leptolineatus* (Indonesian wobbegong shark; Last *et al.*, 2010a), *Hemiscyllium halmahera* (Halmahera epaulette shark; Allen *et al.*, 2013), and *Atelomycterus erdmanni* (Spotted-belly catshark; Fahmi & White, 2015).

The most comprehensive study on the biodiversity of elasmobranchs in Malaysia had been conducted by Yano *et al.* (2005) from 1999 to 2004. The study recorded 56 sharks, 52 rays and two chimaeras. Last *et al.* (2010a) conducted a study in Malaysian Borneo and described two new species of sharks. Ali *et al.* (2013) reported that 63 sharks, 77 rays and five skates were recorded in Malaysian waters. Since 2005, only two new species have been described from Malaysian waters namely *Glyphis fowlerae* (Compagno, White, & Cavanagh 2010; Borneo River shark) and *Cephaloscyllium sarawakensis* (Yano *et al.*, 2005; Sarawak pygmy swellshark).

The first study on chondrichthyans taxonomy in Myanmar had been sponsored by SEAFDEC from 2003 to 2004. Moe & Thein (2006) reported that 32 species of sharks were recorded at two study sites during the study period. Ali *et al.* (2013) listed 34 species of sharks and 46 species of rays in Myanmar.

A survey by Krakstad *et al.* (2014) in Myanmar waters from 13 November to 17 December 2013 recorded 17 species of sharks. Recent study conducted by Robert *et al.* (2015) at several sites, as well as review of literatures, recorded 58 species of sharks. A magnificent catshark *Proscyllium magnificum* Last & Vongpanich (2004) was described based on several specimens collected from Myanmar waters.

In Thailand, research on elasmobranch has been started since 1934. Smith (1945) reported that six elasmobranch species were found in freshwater rivers in Thailand including two species of sawfishes. Monkolprasit (1984) described 67 species from four orders and 13 families of elasmobranchs found in Thailand waters. Vidthayanon (2002) reported that 145 species of elasmobranch, comprise 74 sharks and 70 batoids, inhabit Thailand waters. A recent study conducted by Krajangdara (2017) listed 76 species of sharks, 77 species of rays, and five species of skates found in Thailand waters. Herre (1953) reported that 52 species of sharks were found in the Philippines

waters. Compagno *et al.* (2005) recorded 94 species of sharks and 66 species of batoids inhabit Philippines waters. However, a research sponsored by SEAFDEC from 2003 to 2004 at four landing sites recorded eight species of sharks and two species of rays only (Barut, 2006). According to Last *et al.* (2010b), 139 species of sharks and rays inhabit the Philippines waters. Since 2011, at least two new species have been described from the Philippine waters namely *Squatina caillieti* Walsh (Ebert & Compagno, 2011; Philippines angelshark) and *Pristiophorus lanae* (Ebert & Wilms, 2013; Lana's sawshark).

From 2003 to 2004, SEAFDEC had sponsored a data collection project at two landing sites in Vietnam, where only 13 species of sharks were recorded (Long, 2006). In another survey using drift net conducted in 2004, 21 species of sharks were recorded in Vietnam (Cuong & Vu (2005). Based on all information, the verified list of biodiversity of sharks in this region is shown in Table 1.

Table 1. Diversity of shark species based on order and family levels, recorded in Brunei Darussalam (B), Cambodia (C), Indonesia (I), Malaysia (MY), Myanmar (MN), Thailand (T), the Philippines (P), and Vietnam (V)

| Order/Family/ Common Name                 | No of Species | B        | C        | I         | MY       | MN       | T        | P         | V         |
|---|---------------|----------|----------|-----------|----------|----------|----------|-----------|-----------|
| <b>HEXANCHIFORMES</b>                     | <b>3</b>      | <b>0</b> | <b>0</b> | <b>3</b>  | <b>3</b> | <b>1</b> | <b>2</b> | <b>3</b>  | <b>3</b>  |
| <b>(Cow And Frilled Sharks)</b>           |               |          |          |           |          |          |          |           |           |
| Hexanchidae                               | 3             | 0        | 0        | 3         | 2        | 1        | 2        | 3         | 3         |
| (Sixgill and Sevengill Sharks)            |               |          |          |           |          |          |          |           |           |
| <b>ECHINORHINIFORMES (Bramble Sharks)</b> | <b>2</b>      | <b>0</b> | <b>0</b> | <b>0</b>  | <b>0</b> | <b>1</b> | <b>1</b> | <b>1</b>  | <b>0</b>  |
| Echinorhinidae                            | 2             | 0        | 0        | 0         | 0        | 1        | 1        | 1         | 0         |
| (Bramble Sharks)                          |               |          |          |           |          |          |          |           |           |
| <b>SQUALIFORMES (Dogfishes)</b>           | <b>44</b>     | <b>3</b> | <b>1</b> | <b>24</b> | <b>4</b> | <b>6</b> | <b>4</b> | <b>23</b> | <b>10</b> |
| <b>(Pending confirmation)</b>             |               | <b>1</b> | <b>1</b> |           | <b>1</b> | <b>1</b> | <b>2</b> | <b>2</b>  |           |
| Squalidae                                 | 14            | 1        | 0        | 7         | 2        | 2        | 3        | 7         | 4         |
| (Dogfish Shark)                           |               |          |          |           |          |          |          |           |           |
| Centrophoridae                            | 13            | 1        | 0        | 8         | 1        | 3        | 0        | 9         | 2         |
| (Gulper Sharks)                           |               | 1        |          |           |          |          |          |           |           |
| <b>(Pending confirmation)</b>             |               |          |          |           |          |          |          |           |           |
| Etmopteridae                              | 8             | 0        | 0        | 3         | 0        | 0        | 1        | 3         | 2         |
| (Lantern Sharks)                          |               |          |          |           |          |          |          |           |           |
| Oxynotodae                                | 1             | 0        | 0        | 1         | 0        | 0        | 0        | 0         | 0         |
| (Prickly Dogfish)                         |               |          |          |           |          |          |          |           |           |
| Somniosidae                               | 3             | 0        | 0        | 2         | 0        | 0        | 0        | 1         | 0         |
| (Sleeper Sharks)                          |               |          |          |           |          |          |          | 1         |           |
| <b>(Pending confirmation)</b>             |               |          |          |           |          |          |          |           |           |
| Dalatidae                                 | 5             | 1        | 1        | 3         | 1        | 1        | 0        | 3         | 2         |
| (Kitefin Sharks)                          |               | 1        | 1        |           | 1        | 1        | 2        | 1         |           |
| <b>(Pending confirmation)</b>             |               |          |          |           |          |          |          |           |           |
| <b>PRISTIOPHORIFORMES (Saw Shark)</b>     | <b>1</b>      | <b>0</b> | <b>0</b> | <b>0</b>  | <b>0</b> | <b>0</b> | <b>0</b> | <b>1</b>  | <b>0</b>  |
| Pristiophoridae                           | 1             | 0        | 0        | 0         | 0        | 0        | 0        | 1         | 0         |
| (Saw Shark)                               |               |          |          |           |          |          |          |           |           |

|   |            |          |          |            |           |           |          |           |           |
|---|------------|----------|----------|------------|-----------|-----------|----------|-----------|-----------|
| <b>SQUATINIFORMES (Angelsharks)</b>                                     | <b>8</b>   | <b>2</b> | <b>0</b> | <b>3</b>   | <b>1</b>  | <b>1</b>  | <b>2</b> | <b>2</b>  | <b>2</b>  |
| Squatinae<br>(Angelsharks)  | 8          | 2        | 0        | 3          | 1         | 1         | 2        | 2         | 2         |
| <b>HETERODONTIFORMES<br/>(Bullhead Sharks)</b>                          | <b>1</b>   | <b>1</b> | <b>1</b> | <b>1</b>   | <b>1</b>  | <b>0</b>  | <b>1</b> | <b>1</b>  | <b>1</b>  |
| Heterodontidae<br>(Bullhead Sharks)                                     | 1          | 1        | 1        | 1          | 1         | 0         | 1        | 1         | 1         |
| <b>ORECTOLOBIFORMES<br/>(Carpet Sharks)</b>                             | <b>20</b>  | <b>8</b> | <b>8</b> | <b>16</b>  | <b>9</b>  | <b>9</b>  | <b>1</b> | <b>8</b>  | <b>10</b> |
| Parascylliidae<br>(Collared Carpetsharks)                               | 1          | 0        |          | 0          | 0         | 0         | 0        | 1         | 1         |
| Orectolobidae (Webbegongs)  | 5          | 0        | 0        | 3          | 1         | 0         | 2        | 1         | 1         |
| Hemiscylliidae<br>(Longtailed Carpet Sharks)                            | 11         | 5        | 5        | 10         | 5         | 6         | 5        | 3         | 5         |
| Ginglymostomatidae<br>(Nurse Sharks)                                    | 1          | 1        | 1        | 1          | 1         | 1         | 1        | 1         | 1         |
| Stegostomatidae<br>(Zebra Sharks)                                       | 1          | 1        | 1        | 1          | 1         | 1         | 1        | 1         | 1         |
| Rhincodontidae<br>(Whale Sharks)  | 1          | 1        | 1        | 1          | 1         | 1         | 1        | 1         | 1         |
| <b>LAMNIFORMES<br/>(Mackerel Sharks)<br/>(Pending confirmation)</b>     | <b>11</b>  | <b>1</b> | <b>0</b> | <b>10</b>  | <b>2</b>  | <b>4</b>  | <b>7</b> | <b>8</b>  | <b>5</b>  |
| Mitsukurinidae<br>(Goblin shark)  | 1          | 0        | 0        | 1          | 0         | 0         | 0        | 0         | 0         |
| Odontaspidae<br>(Sandtiger Sharks)                                      | 2          | 0        | 0        | 2          | 0         | 0         | 1        | 1         | 1         |
| Pseudocarchariidae<br>(Crocodile shark)                                 | 1          | 0        | 0        | 1          | 0         | 0         | 0        | 1?        | 1?        |
| Megachasmidae (Megamouth Sharks)  | 1          | 0        | 0        | 1          | 0         | 1         | 1        | 1         | 1         |
| Alopiidae<br>(Thresher Sharks)  | 3          | 0        | 0        | 2          | 1         | 2         | 3        | 3         | 2         |
| Lamnidae<br>(Mackerel Sharks)<br>(Pending confirmation)                 | 3          | 1        | 0        | 3          | 1         | 1         | 2        | 3         | 1         |
| <b>CARCHARHINIFORMES<br/>(Ground Sharks)<br/>(Pending confirmation)</b> | <b>107</b> | <b>3</b> | <b>1</b> | <b>57</b>  | <b>48</b> | <b>42</b> | <b>4</b> | <b>49</b> | <b>39</b> |
| Scyliorhinidae<br>(Catsharks)<br>(Pending confirmation)                 | 39         | 2        | 1        | 12         | 9         | 4         | 6        | 14        | 6         |
| Proscylliidae<br>(Finback Catsharks)                                    | 4          | 0        | 0        | 1          | 1         | 2         | 1        | 3         | 2         |
| Triakidae<br>(Hound Sharks)   | 14         | 1        | 0        | 4          | 4         | 3         | 4        | 5         | 2         |
| Hemigaleidae<br>(Weasel Sharks)   | 5          | 4        | 3        | 4          | 4         | 5         | 5        | 3         | 4         |
| Pseudotriakidae<br>(False Catsharks)                                    | 2          | 0        | 0        | 1          | 0         | 0         | 0        | 1         | 0         |
| Carcharhinidae<br>(Requiem Sharks)<br>(Pending confirmation)            | 39         | 2        | 1        | 31         | 27        | 25        | 2        | 21        | 22        |
| Sphyrnidae<br>(Hammerhead Sharks)                                       | 4          | 3        | 2        | 4          | 3         | 3         | 4        | 3         | 3         |
| <b>Total Species</b>  | <b>196</b> | <b>4</b> | <b>2</b> | <b>114</b> | <b>68</b> | <b>64</b> | <b>7</b> | <b>96</b> | <b>70</b> |
| <b>Pending confirmation</b>   |            | <b>5</b> | <b>6</b> |            |           |           | <b>6</b> |           |           |
|   |            | <b>1</b> | <b>1</b> | <b>3</b>   | <b>1</b>  | <b>3</b>  | <b>4</b> | <b>7</b>  | <b>4</b>  |

Table 2. A summary of shark species recorded in eight Southeast Asian countries

| Country           | Order | Family | Species |
|-------------------|-------|--------|---------|
| Indonesia         | 7     | 27     | 114     |
| Philippines       | 7     | 9      | 27      |
| Thailand          | 8     | 21     | 76      |
| Vietnam           | 7     | 23     | 70      |
| Malaysia          | 7     | 19     | 64      |
| Myanmar           | 8     | 19     | 64      |
| Brunei Darussalam | 6     | 15     | 45      |
| Cambodia          | 5     | 10     | 26      |
| Total species     |       |        | 196     |

Table 2 shows a summary of 196 shark species recorded in eight Southeast Asian countries. Based on the shark species was identified, many species still need to be confirmed and most probably misidentified. This includes seven species from the Philippines, four species from Vietnam and Thailand, three species from Indonesia and Myanmar, and one species from Brunei Darussalam, Cambodia and Malaysia.

Ground sharks (order Carcharhiniformes) is the most diverse order with 104 species recorded in the region. Indonesia recorded the highest diversity with 55 species followed by Thailand and the Philippines with 49 species, Malaysia (48), Myanmar (42), Vietnam (39), Brunei Darussalam (30) and Cambodia with 16 species. Other diverse sharks are from Order Squaliformes (dogfish) with 43 species followed by carpet sharks (Order Orectolobiformes) with 20 species and mackerel sharks (Order Lamniformes) with 11

species. Family Carcharhinidae (requiem sharks) is the most diverse with 38 species. Thirty-one species recorded in Indonesia, 29 species in Thailand, 27 species in Malaysia, 25 species in Myanmar, 22 species in Vietnam, 21 species in the Philippines, 20 species in Brunei Darussalam and 10 species in Cambodia.

Table 3 shows the summary of habitat preferences and their number of species based on several categorizes recommended by Compagno (2002) and Last & Compagno, (2002). In general, 83 species of sharks (42.3%) inhabit continental/insular shelves (SHL) followed by continental/insular slopes (SLO) with 48 species (24.5%), shelf to slope (SHS) with 26 species (13.3%), and shelf to oceanic (SHO) with 16 species (8.2%). Nine shark species (4.6%) inhabit oceanic habitat only and six species or 3% of total shark species obligately live in freshwater and euryhaline freshwater/shelves only.

Table 3. Summary of habitat preferences and their number of species in the Southeast Asian Region. The classification is as suggested by Compagno (2002) and Compagno & Cook (1995)

| Code  | Habitat                       | No of Species | Percentage (%) |
|-------|-------------------------------|---------------|----------------|
| FWO   | obligate freshwater           | 3             | 1.5            |
| OCE   | oceanic                       | 9             | 4.6            |
| SHF   | euryhaline freshwater/shelves | 3             | 1.5            |
| SHL   | continental/insular shelves   | 83            | 42.3           |
| SHO   | shelf to oceanic              | 16            | 8.2            |
| SHS   | shelf to slope                | 26            | 13.3           |
| SLO   | continental/insular slopes    | 48            | 24.5           |
| SOC   | slope to oceanic              | 1             | 0.5            |
| SSO   | shelf to semi-oceanic         | 5             | 2.6            |
| WRH   | wide range of habitats        | 2             | 1.0            |
| Total |                               | 196           | 100            |

### Discussion

The Southeast Asian region is rich with shark species due to its position which covers many seas, such as South China Sea, Gulf of Thailand, Sulu Sea, Philippine Sea, Celebes Sea, Flores Sea, Makassar Strait, Karimata Strait, Java Sea, Malacca Strait, Andaman Sea, Indian Ocean, and western part of Pacific Ocean. Its coastal waters are rich ecosystems

characterized by the existence of areas with extensive coral reefs and seasonal upwelling, as well as nutrient from land. These areas are suitable for breeding, pupping, nursing, and growing of wide diversity of fish species including sharks. He current number of shark species recorded are 196 species, but new species has been continuously discovered, so the species number is potentially increase in the future. Deep water species are mostly unknown due to limited

research activities, especially in Malaysia, Cambodia, Myanmar, and Vietnam. The dominant species of sharks in most countries are almost similar because most fishers use trawl nets except for Indonesia, the Philippines and Vietnam. Fishers in these three countries also catch deep water sharks using longline and deep water gillnets while most fishers in other Southeast Asian countries only fish in the shallow coastal areas using trawl nets.

## CONCLUSION

A total of 196 species of sharks from nine orders and 30 families have been recorded inhabiting this region from freshwater to deep-ocean. The identified deep water species are much less frequent due to limited research activities, especially in Malaysia, Thailand, Cambodia, Myanmar and Vietnam. The number of species will increase in the future if more comprehensive research will be conducted in deeper water. Shark habitats in the Southeast Asian region mostly located within continental/ insular shelves (SHL) and continental/insular slope (SLO) that are now heavily exploited by traditional and modern fishing gears. Exploitation of juvenile sharks is a common phenomenon in all countries in the region, especially as bycatch in trawl fishery. Since all countries have tropical multispecies fisheries, it would be impossible to focus on individual resource, or specific mono-species stock of fish. Management of fisheries resources in this region is now implemented as a whole. All countries should take action to incorporate shark management measures within their national fisheries management policy and framework for sustainable utilization of this resource.

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