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Boon or Bane? The Significance of Scientific Knowledge and Education Consciousness for Crocodylian Conservation in Malaysia

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A fundamental scientific apprehension of the exact nature of crocodiles, combined with the awareness through education for these reptiles could provide a crucial opportunity to enhance the conservation efforts in Malaysia. In this review article, we emphasised that there is a necessity to safeguard estuarine crocodiles (*Crocodylus porosus*) and the Malayan gharials (*Tomistoma schelegii*) in the local ecosystem. More so, we aim to propose sustainable protection standards for these reptiles. We reviewed selected scientific studies related to crocodylians, and resources with regard to local environmental education and overall wildlife conservation efforts. We deem that the exposure to crocodylian scientific knowledge is exceptionally rare in Malaysia as compared to other wildlife. We argue that the erosion of knowledge will have adverse impacts in safeguarding the species. The discussion further highlighted the need to redress existing biodiversity policies and foregrounding formal biodiversity curriculum and literacy for constructive nature ownership in Malaysian schools.

Keywords: crocodylian; scientific knowledge; crocodile conservation; biodiversity curriculum

I. INTRODUCTION

The affairs of human-wildlife conflicts have been on the rise globally (Woodroffe *et. al.*, 2005; Distefano, 2008), and crocodylians have long been viewed as the largest contributors in human-wildlife conflicts (Lamarque *et al.*, 2009). In the Malaysian context, crocodile topics and sightings are much more prevalent in the Borneo states of Malaysia (Sabah and Sarawak) as their distribution is wider and they are found in almost all river basins in those zones (Figure 1). According to Chiew *et al.* (2013), there are a total of 22 major river basins that are accounted for, spreading across an impressive 12 million hectares in Sarawak alone. Some sightings of crocodiles are also regularly spotted in the Peninsular areas, but this happens on considerably smaller scales. Notably, the species in the Borneo states are mostly the *Crocodylus porosus,* which is also known as saltwater or estuarine crocodiles. Locally, the given name for *C. porosus* is Buaya[1] Katak or Buaya Air Masin. Another species that is commonly found in Sarawak is *Tomistoma schlegelii*, otherwise known as Buaya Jelujung in the local context (Hassan *et. al.*, 2016; Stuebing *et al.*, 2006).

[1] *Buaya* is the Malay term for crocodile and the word was used in Maxwell W. E's (1907) work.

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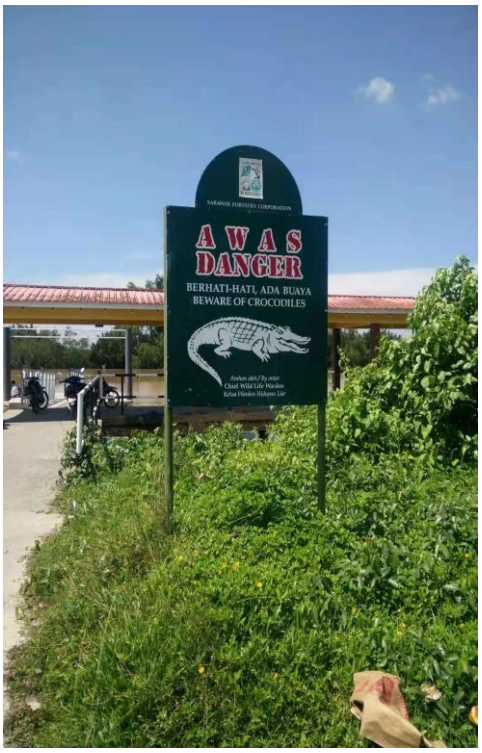

Figure 1. A crocodile 'Danger' sign board by the river in Lundu, Sarawak. (Credit: Lim Tze Tshen)

In spite of the rising human-wildlife conflicts in the aforementioned regions, we reckon that having extensive scientific knowledge and adequate education awareness on biodiversity and ecological systems with regard to the perceived dangerous and life-threatening reptiles can't be ignored. The factors could potentially be the major keys to connect bridges, and reduce the widening gap between crocodiles and mankind. Fundamentally, in order to visualise the conservation management capacities for a developing country that is ultra-rich in biodiversity and wildlife like Malaysia, we need to firstly comprehend the magnitude of having accurate scientific knowledge in enabling efficacious conservation efforts; followed by the impact that can be made if these core components are successfully wielded into our local context. Nonetheless, according to the Malaysian National Policy on Biological Diversity 2016-2025, several shortcomings have been identified in the local ecosystem, including a scarcity in biodiversity knowledge and insufficient levels of awareness on its importance. Additionally, it was also highlighted that issues related to funding and the inability to oversee the enforcements needed to manage them properly have contributed to the policy's inefficiency (Ministry of Natural Resources and Environment, 2016). Similarly, the United Nations Educational, Scientific and Cultural Organisation (UNESCO) has also listed several factors that are proving to be a hindrance in gathering biodiversity data that are accurate and reliable, such as funding resources, shortage of field experts, inadequate data sharing within relevant parties and organisations, followed by a paucity in the understanding of appropriate methods to collect and process information in order to mobilise decision making process. Additionally, UNESCO has also emphasised on the need to have interdisciplinary research and collaboration that partly includes natural and social sciences in order to understand the erosion of biodiversity from different perspectives and initiate rehabilitation processes (UNESCO, 2019).

Consequently, taking into consideration of such accounts, we ask several inconclusive questions such as why is there a need to protect wildlife? Do we humans need to equip ourselves with biodiversity knowledge? In this context, is it a necessity to preserve crocodiles' livelihood? Will protecting crocodiles indirectly impose dangers to humans? Similarly, van der Ploeg *et al.* (2011) also pondered upon the obligations towards protecting crocodiles, especially among rural communities. In the Philippines, the killings of these reptiles have been conducted intentionally due to their supposedly threatening behaviours; to which the aforementioned authors firmly stipulated that the reason why conservationists often find themselves at cross-ends in trying to explain the need to safeguard crocodiles is due to their incapability to convince humans to pursue those ethical actions. Even so, protecting crocodiles did become a heated debate, where the act has been said to only benefit the superiors who suggested the ideas. Certain parties have liken the whole concept to a more westernised ideology, rather than to those who co-exist around the reptiles' home grounds, who commonly originate from the rural, poverty-stricken and marginalised communities in third world countries (van der Ploeg *et al.*, 2011). In short, it can be trivial to those who do not see the significance of preserving crocodiles and hence making further attempts extremely difficult. At present, we noticed that studies on crocodylian protection and conservation in the Malaysian ecosystem are extremely insubstantial and the efforts in educating the urban and rural communities on this subject matter are relatively unknown. This has sparked

curiosity on the level of education and awareness available on crocodylians locally. For example, are people aware of why this species tends to attack humans in the first place? Are they seriously in the hindsight to maul humans to death? And if humans are more educated on the aspects of crocodile nature and behaviours, will the occurrences of such incidents be preventable and spark a caring attitude towards preserving them instead?

Above all, we also recognise that nature awareness is being constantly carried out on wildlife conservation efforts in Malaysia, but a brief examination of the projects involved showed a tendency towards other endangered species such as the Malayan tiger, the Orang Utan and turtles. In light of such developments, these have given us more plausible reasons to emphasise on crocodiles as species that must be protected as well. Moreover, this requires wildlife experts and conservationists to be more observant in establishing the connections between knowledge and awareness while actively pushing for better biodiversity policies and educational programmes in the country. Henceforth, having this in mind, there is a pivotal need to push for effective wildlife protection policies in Malaysia, together with a biodiversity-led environmental education, which we believe will play a vital part in this new decade for greater wildlife conservation efforts in the country.

Primarily, this paper is not an assessment of the country's management capacities and policy responses in regard to wildlife protection and conservation efforts. Rather, we are determined to explore how Malaysia could gain ground in successfully reaching the human-wildlife harmonic dynamism against the backdrops of globalisation in the 2020s. Essentially, this provided us with a platform to further explore the current level of scientific knowledge and education awareness of crocodiles among Malaysians through analysing existing data from journals and web resources. With this, we have specifically chosen to provide an overview on how the extent of these two factors could also be utilised in the field of wildlife research, education and conservation efforts. We expect this paper to crucially explain and expose the significance, advantages and values in intrinsically protecting and preserving crocodiles in Malaysia.

II. METHODOLOGY

In this paper, we mainly adopted an unsystematic narrative review method that was proposed by Green *et al.* (2006). We deemed this method as appropriate in reviewing the numerous resources available with the utilisation of the 'best synthesis approach' for a wide array of contents, at a total of 69 resources such as from: (i) peer-reviewed journals, (ii) website articles, (iii) government documents, (iv) books and (v) online reports that are related to the grounds of crocodiles, conservation efforts, biodiversity and education awareness. This was also achieved by employing a Boolean search approach by inserting relevant and important keywords into the search engine.

Also, the present outlook of awareness through education in nature, especially in schools was particularly guided by observations and impacts from environmental projects conducted in government secondary schools from 2018-2019 by the second author, followed by data from existing studies, which allowed us to evaluate and propose future prospects in strengthening wildlife, biodiversity and environmental education.

III. SCIENTIFIC STUDIES ON CROCODILES

The earliest scientific work on crocodiles of Malaysia can be traced back to an article that was published in 1844. Müller and Schlegel have described the *Crocodylus raninus* from the basis of an adult and a juvenile skull collected by a French naturalist, Pierre Menárd Diard. The skulls were thought to have originated from Pontianak, at the west Kalimantan part of Borneo. It was also noted that many of the collected crocodile specimens in 1836 by Müller were stored in the Muséum d'Histoire Naturelle des Pays-Bas, as recorded in van Lidth de Jeude (1898). Meanwhile, Ross (1990) assigned another *C. raninus* based on the specimen collected by William T. Hornaday in 1878. Ross (1992) further designated the specimen he described in 1990 as a lectotype. Also, the taxonomic status of *C. raninus* of Borneo has been debatable and controversial. Furthermore, surveys conducted in 1995 and 1996 did not discover any *raninus* materials, except for two specimens that were thought to be from the *raninus*-group, specifically from the crocodile farm in Pangkalanbun, central Kalimantan (Ross *et al.*, 1998). Despite these, Das and

Charles (2000) have described a specimen of *raninus* from a skull of a juvenile individual, collected by Webber Booth in 1990 from the shores of Tasek Merembun, Tutong, Brunei Darussalam. On the other hand, to date, only a single specimen of *C. siamensis* from Peninsular Malaysia was recorded (Smith, 1919) and there are no documented records neither from Sarawak nor Sabah (Sebastian, 1993).

Besides that, Banks E. (1930), who was once the curator of the Sarawak Museum, recorded measurements of 41 estuarine crocodiles. These crocodiles were collected mainly from the tidal portions of western Sarawak. A significant discovery was noted in the sense that one of the reptile's stomachs that was dissected contained vegetables and fruits.

Also, research on the crocodile population in Malaysia is inadequate and is mostly from the 80s and 90s period. Studies on it have almost been neglected, raising concerns on where these species stand and co-exist against the backdrops of current development. Having said that, the works related to density distribution surveys and ecological aspects on either types of crocodiles, such as the *C. porosus* and *T. schlegelii* were documented in numerous scholars' studies, such as Cox and Gombek (1985), Stuebing *et al.* (1994), Simpson *et al.* (1998), Stuebing *et al.* (2003), Stuebing *et al.* (2006), Nazli *et al.* (2009), Bezuijen *et al.* (2010), Gani and Hassan (2013), Pine (2013), Gani (2014), Zaini *et al.* (2014), Hassan *et al.* (2016), and Hassan *et al.* (2018).

Precisely, Evans *et al.* (2016) conducted surveys using drones on *C. porosus* nesting in the Lower Kinabatangan, Sabah. Additionally, Fitri *et al.* (2018), Fitri *et al.* (2020) and Moore *et al.* (2020) mainly studied the crocodiles' reproduction and conservation work. Apart from that, Md Adzhar and Hassan (2017) researched the relationships among *T. schlegelii* in Malaysia based on gene analysis. A comprehensive taxonomic study of *C. porosus* and *T. schlegelii* from western Sarawak was documented in Hassan *et al.* (2018). Aside from that, Sah and Stuebing (1996) conducted a research study on diet, growth and movements of juveniles of *C. porosus* in the Klias River, Sabah.

Other significant studies included Matthew *et al.* (2011) report on the breedings of *T. schlegelii* in the National Zoo of Malaysia. Datu (2014) reported short research on the local community's attitudes towards crocodiles and human-crocodile conflicts in Sarawak. Sideleau (2019) summarised a preliminary analysis of recent crocodile attacks in Borneo using data collected from CrocBITE (the worldwide crocodylian attack database) and from local news media from 2007-2017.

Additionally, work on human-crocodile conflicts, especially in the Malaysian Borneo states were documented by Lading (2004), Dacey (2010), Jet *et al.* (2012), Hassan and Abdul Gadin (2013), Lading (2013), Tisen *et al.* (2013) and Tisen *et al.* (2014).

Miranda (2020) reported preliminary research on the Palawan's crocodiles, which shows there are clues that crocodiles migrated from one area to another, and in this case the crocodiles recorded in Palawan were from Sabah, Malaysia.

Through some of these aforementioned authors, we currently have an understanding that the existence of *T. schlegelii* in the Peninsular are in the western and central parts of areas such as in the Kinta River, Bera Lake and some parts of Terengganu. A list of the sightings can also be found in Stuebing *et al.* (2003).

In terms of crocodiles' behaviours and the nature of attacks, Stuebing *et al.* (1985) mentioned that *C. porosus* would steer clear of humans as much as they can. As a matter of fact, the authors stated that crocodiles are smart enough to understand that humans can threaten them the most, therefore, human contacts would be avoided in any possible manner. Hence, this natural instinct of crocodiles can only be defied on the basis of three reasons, such as in the state of being provoked, fearful and lack of food. Normally, these reptiles are more predisposed to consume aquamarine species such as fishes or any other dead corpses. Also, another triggering cause is the breeding environment. Female crocodiles for instance would be very protective of their nest and brood, a result from the increase in hormones. Besides that, during mating seasons, the behaviours of male crocodiles are more exaggerated in order to rival any external invasion of territories, which could explain why some attacks on humans have taken place during this particular time.

IV. NATURE AWARENESS, CULTURAL UNDERSTANDING AND DOCUMENTATION OF CROCODYLIANS

In this particular section, we will first provide an overview on the level of awareness, understanding and knowledge on wildlife, biodiversity and environment in selected Malaysian schools through existing studies. The data from schools on these subjects is extremely important as the rising generation will ultimately be carrying on the responsibilities to safeguard wildlife and nature, and the link between education and awareness must not be underestimated. Also, through the hindsight from these data and findings, improvisation on future wildlife knowledge and conservation efforts can be administered.

A. Awareness, Understanding and Knowledge on Wildlife, Biodiversity and Environment in Malaysian Schools

It is important to note that studies conducted on wildlife and biodiversity learning in Malaysian schools are extremely scarce, and that biodiversity knowledge is not a norm as it is not being taught as a subject, but rather the mere elements of it are being integrated into other courses in topics. Based on the observations conducted in schools from 2018-2019, the term 'biodiversity learning' or 'biodiversity curriculum' are still foreign concepts in Malaysian schools at present, as the education community is much more familiar with the term 'Environmental Education' (EE). EE was first introduced back in 1986 (Said *et al.,* 2007). A look into past records revealed that biodiversity was established in 1983 through a subject called 'Nature and Human'(*Alam dan Manusia*), with an aim to nurture a balanced and harmonic relationship between humans and environment, as stated by Aini *et al.* (2011), as cited in Khairani *et al.* (2020), However, the Nature and Human subject was subsequently terminated in 1995, while EE was integrated as concepts into various other subjects that include moral and religious studies (Ministry of Education, 2004, as cited in Khairani *et al.* (2020)). Additionally, the EE concepts were absorbed into nature clubs and educational campaigns (Zohir *et al.*, 2007, as cited in Khairani *et al.*, 2020). In regard to the concepts of EE in Malaysia at present, Kamaruddin *et al.* (2019) noted that since EE is not being taught as a particular subject in the education system, it does not align with the government's plans to promote environmental sustainability, as the importance on EE is not being emphasised thoroughly with such minimal exposure.

On the other hand, in relation to recent studies on wildlife knowledge, based on surveys conducted by Arumugam *et al.* (2019) in three secondary schools in the state of Perak, Malaysia, the results yielded that upper secondary school students had more knowledge about wildlife as compared to their junior counterparts. Such variances could be due to the taught syllabus, where upper secondary students learn more biology topics. The authors further stated that gender also played a role and it was found that male students were more proactive in this particular field of knowledge. This was said to be due to a lack of outside exposure for female students, which can be seen as a cultural issue where boys are normally considered to be more adventurous and have a knack for uncovering the outdoors; while female students are expected to be more reserved and isolated at home. One crucial fact that was brought up in the study was that the amount of wildlife topics in local textbooks and syllabus are insufficient (Arumugam *et al.*, 2019). Meanwhile, in the state of Sarawak, a study conducted in five primary schools on wildlife knowledge stipulated that there is a significant amount of understanding on the topic of wildlife, mainly due to the fact that wildlife contributes to their livelihood in terms of food resources. However, despite having a handful of knowledge about wildlife and its existence, these students were least familiar with the wildlife's natural habitats (Marina *et al.*, 2019). In terms of awareness of the environment in general, Said *et al.* (2007) mentioned that students in four secondary schools in Johor, Malaysia were aware of issues related to the environment, but a majority of them did not see a need to be overly concerned over the matters. We also probed into non-governmental educational programmes and the World Wildlife Fund (WWF) in Malaysia is currently running the Eco-Schools Programme for EE and sustainable development in approximately 60 schools. Among the activities that have taken place are field trips, conferences and sharing from industrial experts (WWF-Malaysia, n.d).

In what would have been a mutual consensus, these studies all agreed that there is a high priority need to enhance the education of biodiversity, wildlife and environment in local school syllabus as the lack of knowledge is very evident,

although there is a sense of awareness among the students as indicated by Said *et al.* (2007). Since only limited studies are available in these subject matters, therefore the level of awareness, understanding and knowledge can't be generalised to the overall student population in Malaysia, and that the gender effects need to be explored further. But it is very apparent that more needs to be done so that the consciousness, responsiveness and proactiveness behaviours can be gradually cultivated. Aminrad (2013) also mentioned that the Malaysian education system should start considering making EE as an independent curriculum.

V. CONSERVATION EFFORTS

Crocodiles are no longer classified as endangered species in Malaysia, as the number of saltwater crocodiles has reportedly escalated in Sarawak due to successful conservation efforts that began more than 30 years ago in 1980 (Clean Malaysia, 2016). Meanwhile in Sabah, the ban on giving out permits to hunt *C. porosus* approximately 30 years ago has similarly resulted in the growth of the reptiles' population (Clean Malaysia, 2017). However, in a twist of fate, the conservation and protection attempt that began three decades ago seem to have backfired as the large surge in the number of this species has led to a significant number of deaths among locals due to frequent attacks throughout these years. Wong (2016) mentioned that *C. porosus* has an estimated population of 12,000 in a total of 45 rivers in Sarawak. Also, 52 crocodile attacks have been reported, which has resulted in 27 fatalities since 2010. To resolve this issue, a proposal was submitted in 2015 to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), (herein, to be noted as Proposal For The Transfer From the Appendices I to II of *C. porosus* in Malaysia [PTACPM],) in order to allow an existing regulation on the protection levels to be amended from the highest ranking of protection in Appendix I to a more lenient rank in Appendix II (Ministry of Natural Resources and Environment, 2015).

Figure 2. *Crocodylus porosus* at the banks of Sungai Linggi, Rembau, Malacca. (Credit: Lau Ching Fong)

In 2016, the approval was obtained and a change of policy in the conservation stature from CITES has allowed the number of saltwater crocodiles to be trimmed for harvesting purposes. This allows for harvesting of wild crocodiles to be conducted, because the previous CITES protocol only allowed the harvesting of farm crocodiles. In this scenario, only the state of Sarawak has the authority to harvest wild crocodiles, and the permit to do so was not extended to Sabah and Peninsular Malaysia (Kan, 2019). With this outcome, forestry officials sanctioned the killing of the wild species within the Sarawak boundaries in an attempt to curb the attacks on humans, but were limited to 10 selected rivers in the region (Wong, 2016), and the preferences would be given to the locals (Clean Malaysia, 2016). Also, Malaysia did express an interest to continue to engage with international trades for crocodiles due to its high economical values in 2016, but a reassurance was given by the then Ministry of Natural Resources and Environment that the number of existing crocodiles has surpassed the amount estimated for conservation efforts, therefore it should not raise any concerns in regards to preserving them (Clean Malaysia, 2016).

Despite the amendments, the initial proposal still mentioned that in Malaysia, crocodiles are legally protected under existing wildlife laws and trading of crocodiles is strictly limited to legal farms. It was also stated that there have been a number of workshops on human-crocodiles conflict with training that were conducted for those who are in charge of crocodile conservation in Sarawak in order to gain improvised results on management, as stated in the 2015 PTACPM. According to Dhanhyaa (2019), there are three

wildlife regulations within the country that have been designed to protect crocodiles, namely the:

i. Wildlife Conservation Act 2010 for Peninsular Malaysia and Labuan
ii. Wildlife Conservation Enactment 1997 for Sabah
iii. Wildlife Protection Ordinance 1998 for Sarawak

However, an increasingly rampant illegal activities involving wildlife crimes has been raised by some organisations and nature activists, therefore, the Malaysian government has been considering modifying all three existing regulations to limit illegal activities. The author also mentioned that thus far, there are only seven CITES registered crocodile farms that have the authorisation on the handling, management and trades of the animals in this country. Despite that, some registered farms have been criticised for their lack of proper management in terms of sanitation and safety procedures, jeopardising the welfare of the crocodiles and potentially affecting the community nearby as these reptiles could easily escape from captives if flooding happens (Chan, 2018). There have also been calls to audit the farms as cases of illegal smuggling of crocodiles from the wild were found in other parts of Malaysia (Dhanhyaa, 2019).

Meanwhile, Datu (2014) mentioned that the main challenge faced by conservationists is to get the attention of stakeholders to draft relevant policies and dealings in ensuring the species is being secured, given the fact that the number of human casualties could potentially cause a public uproar. However, contrary to normal beliefs that humans can harm crocodiles through commercial exploitation of their economical values and as a result of self-defence, some communities in Sarawak have stayed away from those moves due to ancient traditional laws and taboos that have been passed down from generations (Datu, 2014; Hose & MacDougall, 1901). Datu (2014) also mentioned that those native laws, believed to be a "promise" regulated between the ancestors and the crocodiles, have made these indigenous communities to be of the opinion that there will be repercussions or curses if they harmed the reptiles. In other words, the crocodiles have been regarded as animals with a vengeance soul, hence sparking fear among the locals. Wong (2016) also mentioned that it is almost impossible to have the indigenous or the riverine communities to commit to the killings of crocodiles due to ancestral beliefs that such a majestic reptile holds a supreme power. Understandably, the fear among some of the rural communities have resulted in better conservation moves, and several other researchers (Becker & Ghimere, 2013; van der Ploeg *el al*., 2011; Colding & Folke, 2001) have noted the positive impacts that have been brought over by the installation of such ancient laws. But this fact does not mask the truth that conflicts between mankind and crocodiles are real, and what we aim is to educate people to comprehend why crocodiles are significant in our ecosystem and the roles they play in it. In short, crocodiles can be viewed and perceived differently if we just understood them better, rather than just projecting sheer terror at the thoughts of it.

On the other hand, the conservation efforts in Peninsular Malaysia are limited to a few organisations, such as the Taiping Zoo (Figure 3), the National Zoo, and the Sungai Dusun Wildlife Reserve (Malaysia Traveller, n.d), where breedings of *T. schelegii* have been conducted and studied.

Figure 3. *Tomistoma schelegii* in Taiping Zoo, Perak. (Credit: Lim Tze Tshen)

VI. ECONOMIC VALUES

Approximately from the end of 2016 to 2017, Malaysia has successfully negotiated to be legally allowed to harvest wild crocodiles in the state of Sarawak for the sole purpose of trading, based on the approval obtained from CITES. As previously stated, this was a counter-move by the then government to curb and control the rapid expansion of saltwater crocodiles in Sarawak, a result from an overlooked consequence that rose after years of successful conservation efforts have seemingly created an uncontrollable situation for the locals. In accordance to this, individuals have the capacities to apply and obtain license to hunt wild crocodiles only in the state Sarawak. However, it has been said that the granting of such permission would still be at the discretion of the authorities and each killing would need to be reported. The exact number of licenses that have been approved for hunting purposes in the state of Sarawak is fairly unknown. Besides accessible hunting licenses for wild crocodiles, there is also no doubt on the lucrative booming crocodile farm industry that brings in massive profits to those involved. The largest farm is said to be the Tuaran Crocodile Farm situated in Sabah. According to their website (Tuaran Crocodile Farm, n.d), the farm houses approximately a thousand crocodiles and apart from producing skin and meat. The farm has been advertised as an ecotourism spot as well, attracting visitors to visit and purchase ready-made crocodile-based byproducts (Figure 3). Meanwhile, other well-known farms such as Jong and Langkawi farms have also established themselves as ecotourism sites. On a side note, the only known farm that does not harvest crocodiles is the Teluk Sengat Farm and their sole purpose is to protect and conserve the species in a sanitised environment (Pink, 2019).

Figure 4. Crocodile products from licensed crocodile farms in Sandakan and Tuaran, Sabah. Pictures taken during the 2010 International Workshop on Human-Crocodile Conflict, Kota Kinabalu, Sabah. (Credit: Lim Tze Tshen)

Having said that, in reality, the idea of crocodile conservation has been promoted as a form of sustainable use that can generate income to humans, and similar concepts and mindset have been noted in the Philippines's context by van der Ploeg *et al.* (2011). The researchers mentioned that crocodile ranching for example, is highly capable of providing wages and remunerations in a few countries, with additional incentives being given for conservation and protection efforts. In particular, natives in Papua New Guinea can obtain revenues just by selling infant crocodiles to farms. Due to that, Cox (2009, as cited in van der Ploeg *et al.*, 2011) stated that rural communities have reasons to safeguard the nests. On a positive note, the concept of sustainable use in exchange for income generation can be seen as a way to ensure the livelihood of impoverished rural communities. However, the kinds of incentives available to the natives in Malaysia are almost unknown as the data is not available. At this point of time, only the crocodile farms in Malaysia have been seen to gain income from the direct sales of meat, skin and other products such as medicinal oil, herbal soups, balms, cosmetics and leather goods. Ultimately, what raises concern is that the intention to promote crocodiles' economical values more than any other things could be seen as a move to portray these species as solely significant for their luxurious skin, meat and other by-products. This eventually could result in an act of possible eradication if crocodiles are no longer seen

as beneficial in terms of economic gains. However, despite seeing more extrinsic economical gains, there are definitely intrinsic economical gains where traditional handicrafts featuring crocodiles are still being manufactured as a form of identity, such as the weaved cotton cloth proudly worn during celebrations by the Iban Indigenous group in the state of Sarawak. It is known locally as the Pua Kumbu designs (Figure 5).

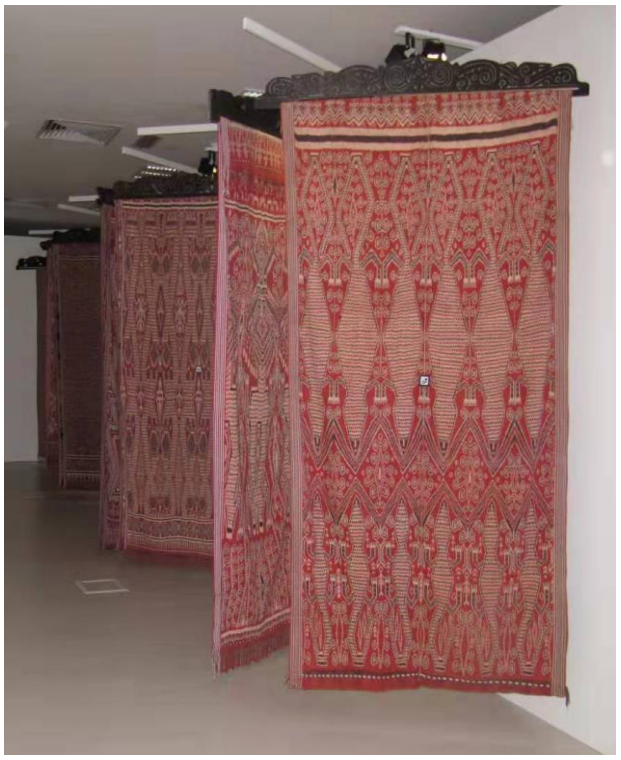

Figure 5. The Pua Kumbu design, which is a traditional weave cloth was exhibited at the University of Malaya as part of a cultural exhibition in 2015. (Credit: Lim Tze Tshen)

VII. FUTURE PERSPECTIVE

A. Policy Responses and Actions for Growth and Enhancement

The past and present deployment of the Malaysian biodiversity planning and policy (2016-2025), followed by the current outlook and impacts of its implementations must be thoroughly reviewed for a new paradigm to take place. We noticed that studies and reviews on the efficiency and effectiveness of the current Malaysian biodiversity planning and policy are extremely lacking at the moment. Furthermore, some of the strategies, acts and regulations with regard to wildlife and biodiversity have to be updated accordingly, and their functionalities should be carefully evaluated and monitored in order to create pathways for the new plans and policies to be drafted as the current one comes to an end term by 2025. Besides that, under the existing Malaysian coastal zone development policy, it is crucial to redress and review ethical developments, specifically at river banks. Violations and improper planning of river banks clearance for the sole purpose to create routes for more resorts or port sites to be built would in turn destroy potential and known crocodile natural habitats and nesting grounds. The mangroves are also a potential nesting site for this species; therefore, the coastal policy should enlist more mangrove areas to be protected from developments. Additionally, the state of Sarawak often builds many hydroelectric dams, which could affect wild crocodiles' ecosystems in the region. In a profound manner, Webb (2014) stated that wildlife conservation should be regarded as being able to direct people more towards achieving potential sustainable measures, rather than the act of overseeing wildlife itself. Hence, the aforementioned issues should be taken into consideration by relevant stakeholders when drafting policies.

B. Create Awareness Through Education and Foster Participation

Our major concern by far would be the efforts to reduce the widening gap and conflicts between humans and wildlife, and to consider developing appropriate resources and materials needed to enhance wildlife, biodiversity and environmental awareness curriculum, especially in schools situated in protected areas and conflict-prone locations. The need to reintroduce biodiversity curriculum in both urban and rural schools should also be carefully coordinated, as the significance of such knowledge and awareness might not be deemed as relevant to those who are not in close encounters with nature. With this, we are emphasising a nationwide implementation of wildlife awareness and biodiversity curriculum in every part of the country as conservation efforts must be seen as a collective act. Indisputably, before such an effort could be integrated into local schools, experts should be first brought in to evaluate the current formal and informal nature curriculum that are being used, and identify the underlying pedagogical and learning issues surrounding the implementation. At this moment, curriculums related to

nature and environment are being taught in science and integrated into other subjects. We envision a more independent curriculum being introduced as supported by local scholars, where knowledge about wildlife, biodiversity and environment are comprehensively taught and exposed. Gradually, it will be a necessity for educators to be trained in these areas as well. It is also vital to note that different schools, depending on their capacities, may need various kinds of approach in carrying out such a curriculum. Therefore, a 'one size fits all' policy in planning this curriculum should be avoided.

C. Effective Attempts on Preservation and Protection

It is essential to ensure that crocodiles and wildlife territories should be identified and not be invaded in any manners. Intrusive acts may provoke and endanger both wild animals and humans. Therefore, in accordance to this, we are suggesting that the government should set up wild crocodiles' rehabilitation centres in the regions, which is a wise move to also inhibit illegal hunting and smuggling of wild crocodiles. Countries like Australia and the Philippines have successful operations of rehabilitation centres in ensuring sustainable conservation and development, which can be emulated by the local authorities. Besides that, although the CITES protocols have been amended to allow the killings and harvesting of wild crocodiles, there has to be an independent body to monitor the activities. Malaysia may have succeeded in the conservation efforts as reported by various parties, but such results may not be sustainable in the long run if proper monitoring is not carried out, as evident from the surge of illegal hunting and smuggling activities brought up by activists.

D. Safety Measures

Presumptively, humans will continue to be very wary of crocodiles and would avoid visiting beaches that have had records of crocodile attacks in the past. Due to this scenario, authorities should have a patrol unit in hotspots to not only protect visitors, but also to ensure businesses that are operating around hotspots will not be affected by negative encounters and reduction of tourists. Also, analysing attack data will be a proactive measure to protect human lives.

E. Legislative and Judicial Modulation

Stringent laws and enforcements on activities related to farming, harvesting, culling, egg collections and seasonal hunting should be a priority within the law-makers and advocates in the country, in addition to setting up human-crocodile conflict protocols. Cases involving violations of wildlife protocols should be handled in strict accordance and punishments to the breaching parties must be strengthened in the country.

F. Enhancing Stakeholders and Local Communities' Engagement and Expertise

More research centres with sufficient manpower and expertise should be established to enable accurate data collection and analysis to be conducted on a regular basis. The government should collaborate with various stakeholders in the gathering and sharing of relevant data and information to allow more knowledge to be generated on effective and sustainable conservation measures. In addition, there should be up to date data on crocodile attacks in systems such as CrocBITE. Authorities should also secure indigenous and local knowledge on wildlife and crocodiles, and absorb local communities to participate in conservation efforts. Thus far, there are no incentives or developmental aids being provided to local communities. Therefore, this must be further evaluated on the effectiveness of such kinds of reward systems in conservation efforts, although providing monetary compensation in exchange for protecting wildlife must be conducted in an ethical manner. We also believe that citizen science programmes in the future can potentially lead to better scientific understanding of crocodiles in the regions. These non-professional scientists and environmentalists can be trained to observe, collect and analyse data, and assist in spreading awareness to the public.

VIII. CONCLUSION

We have attempted to realistically portray and reveal the exact true nature of the crocodilian species in the region. Among all the wildlife that exist in Malaysia, crocodiles are the only species that have been least exposed to the public in terms of their natural habitats and behaviours. In this paper, we also explored the trends, issues and challenges behind

conservation efforts and stated the obligatory requirements for future trajectories. Optimistically, we posit that the novelty of this comprehensive review and discussion will contribute to forthcoming references with regard to Malaysian crocodile research and enhance existing knowledge for crocodile conservation and biodiversity.

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