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Dhole's Ecology and Legal Status: Conservation and Management Implication in Human-Dominated Landscape of Java, Indonesia

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ABSTRACT
The success of conservation and management of endangered species is highly dependent on the manager's understanding on the biology and ecology of the target species. However, most wildlife management and conservation activities in developing countries are not based on scientific data, but more on the political agenda and intuition of managers. As a result, the impact of conservation and management efforts was far from what was expected and sometimes even caused new problems to arise (e.g., the rapid population decline of certain species, introduction of alien invasive species etc.). Wildlife legal status is also important to protect a certain species from exploitation and to ensure the fairness by regulating social conduct and enforcing policy associated with wildlife management and conservation, and, therefore, it has play an important role in achieving management goal. We attempt to review the management and conservation of dholes (*Cuon alpinus*) at the human-dominated landscape through ecological and legal approach. Our finding showed that an approach which was mostly used along the history of dhole's management was lethal control due to livestock depredation. This approach has resulted dramatic decline of dhole's population and explosion of wild ungulates population. In Indonesia, the government regulation to conserve this species is already exists, but lack of implementation due to management limitations. The absence and lack of baseline data for dhole's conservation are common phenomenon since this species has not listed as a priority species. To ensure the long-term survival of this species, suitable conservation strategy supported by good scientific data and regulations related to dhole's conservation is absolutely needed. Gathering scientific data related to the dhole's conservation by the multidisciplinary team will benefit to the management in resolving the problem arises during the management process. The availability of adequate ecological data will also be useful for increasing public understanding in the importance of dhole conservation and attracting public sympathy, thus they become more tolerant to the existence of this species.

Keywords: *Cuon alpinus, Conservation, Ecology, Java, Legal status, Management.*

1. INTRODUCTION

Predators play an important role in maintaining the health of ecosystem by initiating a trophic cascade [1-5], thus, the efforts to restore of apex predators have become an important conservation goal in many ecosystems [4, 6-8]. The interest to restore top predators worldwide is growing as efforts to manage species abundance and ecological processes for the benefit of biodiversity conservation [5, 9-12]. Trophic cascade occurs when at least two trophic levels have been influenced by a consumer in which carnivores directly influence the abundance of herbivores, and then indirectly influence the abundance of primary producers by reducing the impacts of herbivory [2, 3, 5, 13, 14].

High predator diversity can provide a buffer against invasion of invasive species, and native predators tend to have less significant impacts on native prey than invasive predators [9, 15]. The absence of apex predators in an ecosystem may facilitate population outbreaks of native mesopredators and may increase the ecosystem susceptibility to invasive species [7, 16-20], creating pest problem for commercial food industries, and threatening vulnerable prey species [21]. Many pieces of evidence clearly showed that once top predator populations have been retained or restored, they can buffer against and, or ameliorate environmental challenges, including biological invasion, disease transmission and climate change [9, 22-25]. Therefore, restoration of apex predators could be a powerful instrument in regulating the predation's impacts on prey species at lower trophic levels [17, 18, 26].

Despite apex predators have an important ecological role, some of them, especially non-charismatic species, are rarely considered in conservation and wildlife management [27, 28]. The characteristics of the apex predators which associate with large physical size, carnivorous, rare, elusive, fierce and intelligent become threats in the human perception [27]. The oldest reason behind large carnivore persecution is they are instilling fear in people, as they do in their prey [29]. Consequently, the widespread extinctions of a top predator as the results of hunting, persecution by humans, and habitat loss have changed terrestrial ecosystem structures [13, 30]. Therefore, management and conservation of apex predators are among the most controversial wildlife management issues globally [27, 31], particularly when a conflict of interest between human and carnivore still become the main management concern [3, 21, 32, 33]. Human and carnivore conflicts have become an urgent challenge worldwide because these kinds of conflicts often placed human communities against carnivores and against other humans who try to conserve or restore wildlife populations [12, 29, 32]. Wildlife managers have to make a compromise [27] and select options for accommodating the requirements of large carnivores and take into account human interests, especially where the management and conservation efforts were attempted in the human-dominated landscape, such as on Java Island, Indonesia.

Java is one of the most densely populated islands in the world, is habitat for the large carnivores such as Javan tiger (*Panthera tigris sondaica*), leopard (*Panthera pardus*) and dhole (*Cuon alpinus javanicus*) [34, 35]. In the 1940s, Javan tigers were likely disappeared from most of the island and only found in the remote forested area [36]. The cause of extinction includes hunting, loss of forested habitat and decline of prey base, and classified as extinct by IUCN in 2003 [37]. Although a good system of nature reserves located in tiger habitat on Java, which has been established in the mid of 1930s [34], they did not suffice for Javan tiger [36]. Nowadays, only leopard and dhole are remaining survivors on the Island, and if without any appropriate management and conservation treatment of these species, it is likely that they also will follow to go to extinction soon as Javan tiger's case.

The concern of biologist and conservationist toward the dhole's conservation and management are relatively low compared to felids and the other large social canids such as grey wolf (*Canis lupus*) and African wild dog (*Lycaon pictus*) [38]. The generalist and opportunistic behavior of this species have placed this species in the difficult position since it preys on endangered species (e.g., banteng (*Bos javanicus*)) [39-41]. Moreover, the cases of livestock depredation by dholes have led this species to be considered as pest throughout their natural range [34, 42-51]. These facts have resulted the low concern in the conservation effort of this species compared to the other large carnivore in the same habitat [50, 52].

The growing evidence on the important role of top predator in maintaining the healthy ecosystem [9-11, 22-25] has highlighted the importance of dhole's management and conservation. As an example, in Bhutan, the dhole's mass extermination in the 1970s and early 1980s was suspected to be the main cause of wild boar (*Sus scrofa*) population boom and resulting crops damage problem [45, 46]. Dholes were reintroduced in Bhutan in the early 1990s to reduce the wild boar population explosion, and this predator population is now becoming reestablished [45]. In 2003, a study which was conducted by Wangchuk (2004) found that the number of dholes has significantly reduce the number of wild boars in Bhutan. It showed that the existence of dhole in maintaining ecosystem balance is important, and the survival of this species from extinction in the human-dominated landscape relies on the people's understanding of the management and conservation of this species.

The understanding of the ecology of the managed species is essential to make the appropriate management and planning decisions [53, 54]. Conservation activities which are conducted simultaneously with the socio-economic development of the community have been promoted in recent years, but unfortunately many of these activities were still conducted based on the political agenda and intuition of managers, so that the positive impact of these activities on biodiversity is still not significant [53]. Hence, the management effort often resulted in impacts which diverged from the management expectation [9], as have been reported to occur in Australia [20, 55, 56], America [3, 29], and Bhutan [45, 46].

Although scientific based data is very important in supporting managers in achieving management goals, the information that mostly contains statistical data

(e.g., data on abundance, population dynamics, habitat, behavior, and distribution) has little use for local communities or local actors involved in management because it is difficult to understand. Therefore, simpler information is needed, and one of them is information related to policies that regulate the legal status of a species. Wildlife legal status is important to protect a certain species from exploitation and to ensure the fairness by regulating social conduct and enforcing policy associated with wildlife management and conservation, and, therefore, it has play an important role in achieving management goal [106]. In this paper we attempt to discuss about ecological information and legal status of dholes which can be used to support the management and conservation of this species, particularly in Java. Once a species has a legal status, its population become the object of law and all of treatments regarded to the population including the utilization, protection, management (e.g., hunting, ecotourism, and breeding) and conservation are regulated by the law [57].

2. METHODS

Literature review was conducted by searching on the internet using the aid of Google Search Engine to find all published studies concerning dhole ecology and conservation. We used term "dholes (*Cuon alpinus*)" in combination with "ecology" and "conservation. All materials including journals, proceedings, and books were used in the literature review. First, we review the ecological information of dholes from the published scientific papers and books. Second, we discuss the management and conservation which have been conducted on this species. Third, we identify the gap between the available scientific information and the need for management and conservation of this species. Lastly, we suggest an alternative wildlife management actions of this species.

3. DHOLE'S POPULATION IN JAVA

Dhole is considered as the second largest carnivore in Java after Javan leopard (*Panthera pardus melas*) [58]. The study using fossil specimen found that the genus Cuon (*C. alpinus* and *C.* (*Mececyon*) *trinilensis*) has appeared in Java since Pleistocene together with the other carnivore, include leopard, tiger (*Panthera tigris*) and hyena (*Hyaena brevirostris*) [59]. *C.* (*Mececyon*) *trinilensis* was an endemic species that went to extinction during Pleistocene. Hence, today, dhole is the only existence of genus Cuon [60]. The occurrence of the carnivore in Java in Pleistocene period might be caused by the low of sea levels that created extensive corridors between the Asia mainland and Java [61, 62]. Until now, the origin of the dhole's population in Sumatra and Java is enigmatic since from the study of phylogeography, genetic structure, and diversity in the dhole [63] reported that the samples from Java and Sumatra were very distinct from the samples from Malaysia. The lower genetic distance was seen between samples from Sumatra, Java, South Ganges (South, Central and North India), Myanmar and possibly China. From this result, they suspected that there were possibilities of human translocation of dholes from one of these regions into Sumatra of Java. However, to explain the origin of Cuon both in Sumatra and Java requires the further study [63].

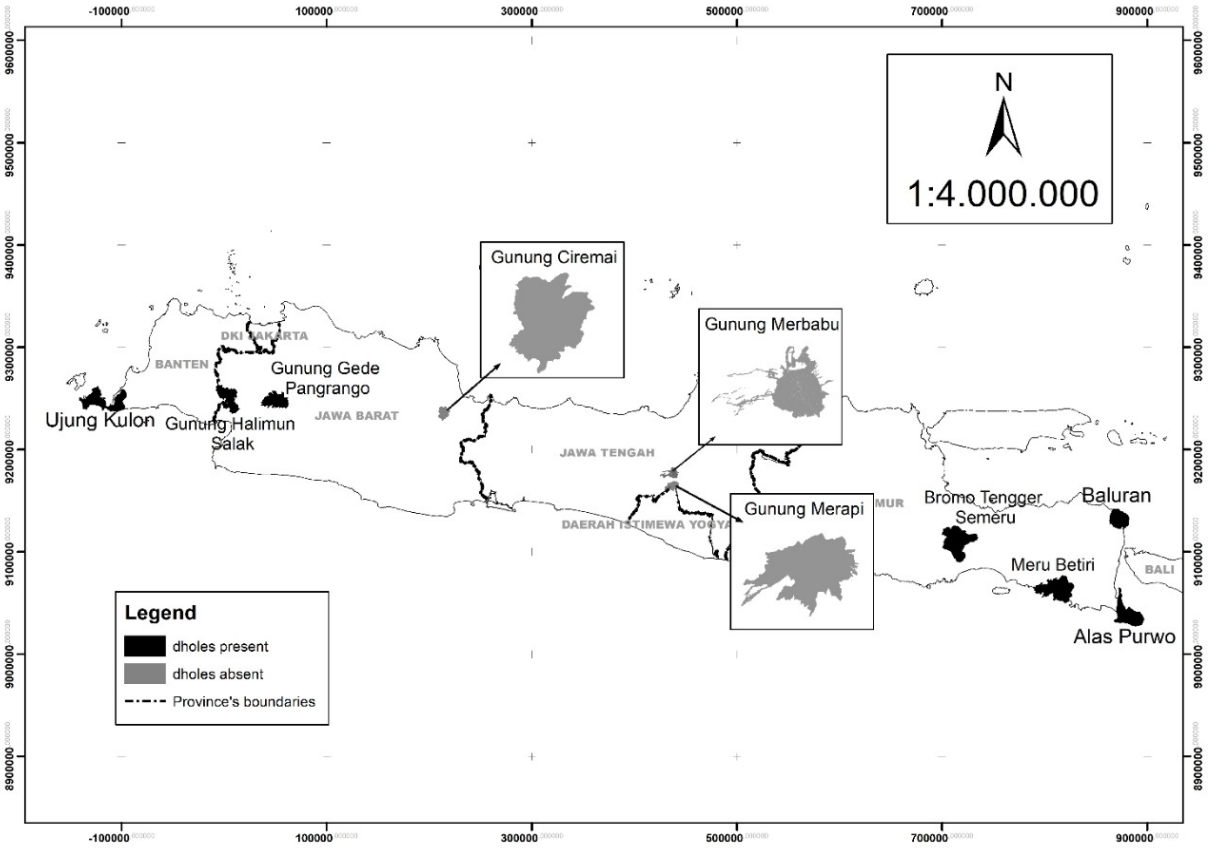

Figure 1. Map of dhole's presence in the national parks on the mainland of Java (official website of Ministry of Environment and Forestry of Republic Indonesia (http://www.dephut.go.id))

Once, this species was widely distributed in Java [34]. Nowadays, its distribution is highly fragmented and mostly exist in the protected areas in the eastern and western parts of the Island [64] (Figure 1). In the eastern parts of Java, dholes mostly appear in the protected areas namely Alas Purwo National Park (APNP) and Baluran National Park (BNP) which are the natural habitat of many prey species including banteng (*Bos javanicus javanicus*) the flagship species of both national parks. In those national parks, dhole is considered as the major top order predator besides the Javan leopard. In 1996, the population size of dhole peaked in APNP and caused the decline of banteng population until 16 individuals from 300-400 individuals [39]. However, because unknown reason, the dhole population declined considerably before any management efforts were taken [39]. Dhole was also suspected as the major cause of the banteng population depletion in the BNP for five years (2002-2006) [41]. The predation of dhole on banteng has resulted in a change of the age composition and the sex ratio of banteng since dholes prefer to kill young and pregnant

Table 1. Status of dhole's occurrence in 10 national parks of the Java Island. The plus (+) represents presence and absent with minus (-).

National Park	Width (km²)		Present
Alas Purwo	434		+
Baluran	250		+
Bromo Tengger Semeru	503		+
Gunung Ciremai	155		-
Gunung Gede Pangrango	150		+
Gunung Halimun-Salak	400		+
Gunung Merapi	64		-
Gunung Merbabu	57		-
Meru Betiri	580		+
Ujung Kulon	1,206	Including 433 km² of water area	+

Source: official website of Ministry of Environment and Forestry of Republic Indonesia (http://www.dephut.go.id)

females [40]. This case has raised issues about dholes conservation in both of national park, due to effect of preying endangered banteng population [65], which implied recommendation to protect the banteng population by reducing dhole pack sizes (Pudyatmoko et al., 2007). Nevertheless, until nowadays, the national park managers still do not make any effort to manage the dhole's populations in both national parks; either supporting to increase population or limit it.

The information on dhole's population in Java is limited. Most of the information only mentioned the presence or absence of dhole in the national parks (Table 1). Only two studies mentioned the population size of dhole's population which were conducted in BNP by Pudyatmoko et al. (2007) and Nurvianto et al. (2015). The first study was conducted in single feeding ground (savanna) (350 ha) and the dholes were observed from a tower located on the top of the hill in the middle of the feeding ground. However, the estimated population of the first study seem to be overestimated [41]. The second study was conducted using the combination of line transect distance sampling which was located systematically across the national park and camera trap survey at 18 waterholes and seven animal trails seem to be more robust compared to the first study. The result of the study showed that there were four packs in BNP, which two of them were successfully bred. The second study also informed that there were plenty of prey availability in BNP. These evident showed that BNP is one of the essential habitats for dhole's population in Java [35]. However, both studies are only covered a small portion of data which are needed to develop management and conservation on this species in Java. Hence, further extended studies in both spatial and temporal scale to capture the population dynamics of this species across the ecosystem of Java are necessary. At least, the indices of abundance of dhole's population in the remaining habitat are needed to monitor the impact management programs or the change of environmental conditions on the population [66].

4. HABITAT

Dholes inhabiting various habitat types in their geographical ranges [64]. In India, dholes use dry deciduous forest and savannah woodlands which interspersed with meadows [48, 67-71], and Dipterocarp Forest [72]. In Thailand, dholes use lowland rainforest [73], mixed evergreen and deciduous forest [74], mountainous semi-evergreen forest [75], and grassland [74] as their habitat. In Bhutan, dholes used the cool broadleaved forest with smaller areas of mixed-coniferous forest, and bamboo stands [43] and temperate mountain ecosystem [44] while in Peninsular of Malaysia, the dholes used tropical evergreen moist forest [76]. In Java, dholes were reported to use different habitat types which range from coastal until mountainous area including savanna, shrubland, coastal forest, mangrove forest, managed forest, deciduous forest, and plantation [34, 77], and mostly attracted to the locations which have plenty of prey, especially deer, banteng and water buffalo [34, 39-41, 78].

There is no existing study proving dholes have any preference in the certain type of habitat type, however, there are evidence that most of their distribution were positively associated with their prey's distribution and negatively associated with the present of anthropogenic activities [38, 49, 71, 74, 77, 79, 80]. In Mudumalai Sanctuary, Southern India, dhole's packs tended to visit patches in pre-determined sequence in one direction and, on reaching the last patch in the sequence, returned to the starting patch, while other patches were visited in a random fashion [38, 71]. Residency time did not differ between patches and ranged from 1 to 7 days. Venkataraman and Johnsingh (2004) [38] suggested that changes in the proportion of individuals vigilant in chital herds were monitored following hunts by dholes in a given patch and revealed that the proportion of individuals vigilant was highest after a hunt. The enhanced vigilance of chital may thus cause a drop in dhole pack hunting success following a hunt and, therefore, packs may shift to fresh patches where vigilance is at base background levels and hunting success is greater [71]. The similar pattern was also found in Java Indonesia whereas the pack visit patches with high prey density such as feeding ground and water pond within its home range [79]. Those cases imply that the habitat availability which can provide sufficient prey availability is important for dhole's survival, hence, the habitat management to support the prey population within the dhole's habitat must be one of the top priorities of management concern as a means to conserve this species.

5. FORAGING ECOLOGY

The dholes' foraging behavior is developed along their life history. Dhole is one of four living canid species (besides wolf, African wild dog, and bush dog (*Speothos venaticus*)) which are considered as a hypercarnivorous animal [81, 82]. Hypercarnivores are defined as species whose diets consist entirely of vertebrate flesh, and characterized by moderately to greatly reduced cheek teeth, emphasis on slicing function in the remaining cheek teeth and relatively short rostra [81]. That is the reason why dholes is restricting their diet to pure flesh, while the dental of most canids most of canids have adapted to omnivorous diets [81, 82]. It is hypothesized that evolution of hypercarnivores occurred during great meat availability, when the other hypercarnivores were rare or absent, and the availability of prey in their habitat are very abundant and diverse [81]. It implies that from the beginning of

their existence, in the late Pliocene periods, the dhole's foraging behavior was adapted to the environmental condition in that era when there was the appearance of extensive areas of grassland which were used as habitat by large ungulates [83]. Further, Valkenburgh (1991) [81] explained that if the evolution of hypercarnivorous canids is constrained is some way by the diversity of other carnivores; then there were "double wedge pattern" in which the rise of one group is associated with the decline of another or a pattern of extinction followed by replacement. The alternative pattern of extinction resulting from extrinsic factors followed by rapid radiation of new taxa suggests an opportunistic process, dependent on the extinction event for its genesis. Dhole's foraging strategy has been proved as a successful strategy that granted their survival since the other Cuon, *C.* (*Mececyon*) *trinilensis* was failed to survive and went extinct in the Pleistocene [59]. The dholes have developed their foraging strategy not only to catch successfully their prey but also to compete with the other predators [81, 84].

Dholes developed the cooperative hunting strategy in their foraging behavior. Cooperative hunting can provide a better fitness advantage to each individual involved compared to hunting alone, even when several individuals have to incur costs in the process (e.g. suffer injuries) [85]. The fitness benefits derived from cooperative hunting appear to arise from effectiveness in capturing prey, the ability to capture larger prey or variations in prey capture rates that are minimized [85]. The cooperative hunting strategy was commonly developed by hypercarnivore canid species such as dhole, wolf, African wild dog and bush dog [81, 82, 85]. Dholes used this hunting strategy, particularly while hunting large prey such as adult chital or sambar. Fox (1984) has described the detailed process of the dholes kill. He found that all of the preys that have fallen showed varying degree of mutilation. They were chasing the prey in a pack. One of them seize the prey by the nose and hold it to inhibit the prey's movements while the other member of pack bites the other prey's body part such as the hind, thigh, buttocks, tail, ears, and flanks. There was no killing bite, and they have no clean and efficient way of killing their prey. The dholes often tear the flesh from its prey and may eat a portion of the prey that is torn off as it struggles while the prey was still alive. When the prey's flank is torn open, the animal is disemboweled as it struggles or is dragged along the ground by its head.

The dholes have several hunting strategies that were adapted to the prey and their environments. The dholes were frequently used ambushing technique from bushes to hunt the small preys such as chital and sambar fawn [49]. While chasing prey for long distances the pack members are often observed to cut corners reducing the distance between prey and the pack [49, 71]. The effort to chase the prey commonly ended within 500 m from starting points, and it needs 2 minutes to kill the 50 kg or fewer preys, and maximum 15 minutes to kill the large stag [49]. The dholes also used the technique to drive the prey that separated from its group into the water and bitten and harassed it in the water until it died [49, 74]. The carcass of the prey was dragged ashore and consumed by all of the pack members. During prey consumption, dholes do not lie around the kill but usually, tear off a piece and run to cover and eat alone. Fox (1984) suggested that this behavior was used to avoid possible human encounters as much as to avoid intra-pack conflict while eating.

Based on the field observation that conducted by Fox (1984), one pack of the dhole contained 20-25 individuals and rarely together and not when hunting. The pack broke into smaller hunting packs of three or more individuals and reassembled in the evenings at the denning area or the site near the denning area. Cohen et al. (1978) observed that one solitary fawn was killed by a pack of 8 dholes and solitary dholes should be most successful at hunting small prey such as rodents and lagomorphs. A chital fawn can be killed by two dholes, while three dholes were successfully killing a sambar fawn and chital doe [69].

Dholes select a range of prey weight in their diet. Several study concerning the feeding habit of dhole have been conducted in Bhutan [43, 44], India [42, 48, 49, 67, 70, 86-88], Malaysia [76], Thailand [74], and Indonesia [78]. The result of the study showed that dhole selected prey weighing 30-175 kg. The average weights of dholes pack: prey body weight ratios was 1 : 0.41, while if the maximum weights of dholes pack and the largest prey killed were considered, the ratio was 1 : 2 [70]. In the selectivity for age-sex classes, dholes showed the highest preference for adult males chital [70] and sambar fawns [48].

The content of the dholes diets is highly influenced by the preys' availability which is available in their natural habitat and varies from places to place [38]. The preys were varying in size and weight; from the small to the big mammal and weighted from less than 2.5 kg to more than 100 kg [43, 44, 67, 70, 74, 76]. In India, dholes prey most frequently on sambar (*Cervus unicolor*), chital (*Axis axis*), muntjak (*Muntiacus muntjak*), hare and other small prey [48, 67, 68, 70, 86, 88], while in Bhutan they prey sambar, muntjak, serow (*Capricornis sumatrensis*) and Goral (*Naemorhedus goral*) [43, 44]; in Thailand, muntjak, wild pig (*Sus scrofa*), sambar and hog deer (*Axis porcinus*) [74, 75] and in Peninsular Malaysia, the Java mouse-deer (*Tragulus javanicus*) [76]. The similar pattern occurred in the relative biomass contribution to the dhole's diet. In Java, dholes mostly prey on buffalo (*Bubalus bubalis*) and rodents, while, in term of biomass contribution, ungulates (buffalo, banteng, Javan deer, wild boar and Indian muntjac) provided more than 95%

of the biomass consumed by dholes [78]. The results of the studies on dhole's diet suggested that the ungulates still have an essential role in dhole foraging ecology, that's means ensuring the availability of ungulates in the dhole's habitat is very important for the conservation of this species.

6. BREEDING ECOLOGY

Female dhole begins to reproduce at the age of three years [89]. Only one individually alpha female received reproductive behaviors from males, despite many females being present in the pack during her tenure [49, 69, 89]. The mean tenure for females was six years, while the tenure for males was two years [89]. The shorter tenure in males enhances their opportunity for anticipating future breeding slot and makes them remain in the pack. The males delay their dispersal and stay in their natal packs because of the potential reproductive strategies they can pursue. In contrast, subordinate female disperses from pack due to suppression of reproduction by alpha female. Venkataraman (1998) observed breeding pairs raising pups without the help of other pack members. One pair was observed raising three pups but none of them survived to the independent age, while the other pair have successfully raised 11 pups to the independent age. The females in both pairs were much younger than the males. Venkataraman (1998) suggested that most likely those pairs were formed by the male and female left their same former pack together or by an accidental meeting of the male and female when they left their former packs as floating individuals.

In the nature, dholes breed normally only once a year and rearing their pups in the earth cavernous dens [49, 89]. The subordinate females in packs act as helper together with subordinate males in rearing pups such as guarding duties and brought food to the pups [90]. Maisch (2010) found that the helper existence gave positive effect to the success in rearing pups. He suggested that as a mammal, the breeding female has to remain in the den with her pups and she requires a lot of energy for milk production, making her even more dependent on helpers. The occurrence of reproductive suppression and communal methods of rearing pups could provide both direct and indirect benefits to pack members. Helping to rear the pups of the dominant pair (alpha pair) means the pack gains indirect fitness [90].

According to Fox (1984) there are four different types of dens, namely: 1) a simple earth den with one entrance, 2) a complex cavernous earth den with more than one entrance, 3) a simple cavernous den with one entrance that was excavated under or between rocks, and 4) a complex cavernous denning area with several dens in the same vicinity, some of which may interconnect. The dholes build their dens by using other animal's burrows which located on steep slopes with dense vegetation cover and far from human activity [49, 79]. The Denning dholes switched den every two weeks [79]. The pups suckling period is approximately 58 days and the pups stay around the den site until they are reach 70-80 days old [49]. Those periods are considered as the critical time for denning dhole when dholes are vulnerable to any disturbance because of their high fidelity to their den [49]. Knowledge of den ecology is very important to support the management and conservation of this species, especially to understand the denning strategies of this species in its habitat that led to its reproductive success [91-95].

7. ACTIVITY AND MOVEMENT PATTERN

Dholes are clasified as diurnal and crepuscular predator. Many studies indicated that the dholes are diurnal predator [68, 70, 71, 76, 82, 86, 96], although there were other studies which considered dhole as a crepuscular predator [73, 97]. They are often seen between 06.30 and 09.00 in the morning and 16.00 and 17.00 in the evening, which is time to make a kill, and the most often hunt and kill happened between 06.00 and 08.00 [48, 49]. In the denning season, most activities in the den intensified at dawn and dusk, and less intensive in the middle of the day when most adult dholes spent the daytime hunting [79]. The temporal activity patterns of dholes were likely to be driven by their prey activities which was mostly diurnal large ungulates [43, 44, 86, 98].

Dhole packs' home range are likely to vary as a function of prey density, composition, and distribution, all of which influenced by habitat types [38]. From the studies that have been established in the three different places in India; Nagarahole, Mudumalai and Bandipur which were characterized by deciduous forest showed that each dholes pack has different home range size. Karanth and Sunquist (2000) have studied the home range size of a dholes pack in Nagarahole using individual pack members with distinguishing physical features, and they recorded the time, location and activity seen during the observation. The result showed that the home range was estimated at 27.5 km^2 (Adaptive Kernel Estimator/AKE), 23.4 km^2 (Minimum Convex Polygon/MCP) and 27.4 km^2 (Harmonic Mean Estimator/HME) with the number of locations are 138 points. Venkataraman et al. (1995) reported that the home range areas for two different packs that amounting 4-18 and 2-25 individuals were estimated at 83.3 and 54.2 km^2 (MCP) respectively with the number of locations are 276,103 points. In Bandipur, a dholes pack which is contained 13 individuals intensely used an area of approximately 20 km^2 covering a maximum area of 40 km^2 and ranging daily from 18 km^2 [49]. Grassman et al. (2005) calculated the home range size of 2 dholes using radio telemetry in the Phu Khieo Wildlife

Sanctuary in north-central Thailand which was characterized by evergreen forest. The result showed that the home range areas were estimated at 12 and 49.5 km^2, respectively using the minimum convex polygon method (number of locations are 39 and 62). In Java, Nurvianto et al. (2015) reported that during the denning season the size of dhole's range was estimated at 744.86 ha (95% MCP), at 1418.28 ha (80% Kernel Utilization Distribution/KUD), and at 479.59 ha (90% Local Convex Hull/LoCoH), in which comprising the most greatly used area that was estimated at 231.57 ha (25% KUD) including the den sites, water resource points and hunting hunting grounds [79].Those results showed dholes need a wider area to support their survival. If we refer to the width of the national park which is occupied by dholes (Table 1), at least 150 km^2 intact area with sufficient resources is needed to support dhole's population in Java. The BNP with 250 km^2 width is reported to be able to support four packs [35], even though more studies are still needed to monitor their long-term survival, particularly the impact of surrounding landscape for conservation of large predator [99].

8. MANAGEMENT AND CONSERVATION

The carnivore management was driven by the need to resolve the conflict between human and carnivores [21, 100]. In general, the conflict emerged along with human colonization activities including food production and the harvesting of wild animals in a certain area which is a part of carnivore's habitat [21, 101]. The predation on people and their livestock have raised the negative responses from the community, and as the result, carnivores have increasingly been subject to retaliation killing [21] and low interest to support for conservation of the carnivores and protected area [101]. Moreover, their characteristic which usually occur at low densities, make carnivores among the first species to be extinct with human alteration of the ecosystem [102].

There are two different approaches to the management of terrestrial carnivore s which are involved in conflict with humans, i.e., lethal approaches and non-lethal approaches [21]. The lethal approaches are used to manage the terrestrial carnivore by culling the animals prior the periods of greatest risk (proactive culling) or removing individuals that are causing damage (reactive culling). Along the history of dhole's management, lethal approaches were likely used to manage its populations as reported to occur in Java during the colonial era [34], in Bhutan in 1970s and early 1980s periods [45-47], in Northeast India [103], in Southern India [49], and in Nepal [50]. However, this approach was ineffective and often failed to alleviate the negative impacts of the predators [104, 105] and lead to the other problems, such as the mesopredators release and the high density of ungulates population which together contribute to ecosystem degradation [12, 30, 45, 46].

Table 2. The list of regulation which stated dholes as protected species according to issued country

Country	Regulation
Cambodia	Protected Area Law 2008
Malaysia	Wildlife Protection Act, 1972
Thailand	Protected Animals, Wildlife Preservation and Protection Act, B.E. 2535 (1992)
Vietnam	Decree 18/HDBT (17/01/1992) and the Amendment Decree 48/2002/ND-DP (22/04/2002)
Bhutan	Forest and Nature Conservation Act, 1995
China	Law of the People's Republic of China on the Protection of Wildlife 2004
India	Wildlife Act, 1972
Indonesia	Presidential Decree No. 43 in 1978 about the endorsement CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) Appendix 2; Act No. 5 in 1990 with respect to the law on the conservation of biodiversity and ecosystems; Government Regulation of the Republic of Indonesia No. 7 in 1999 with respect to the law on the preservation of flora and fauna, in which dhole was mentioned in the appendix point 13; Regulation of the Minister of Environment and Forestry No. P106 in 2018 with respect to the law second change of Regulation of the Minister of Environment and Forestry No. P20 in 2018 with respect to the law on the protected flora and fauna, in which dhole was mentioned in the appendix point 12.

In Indonesia, especially Java, the actual events of livestock depredation by dholes have never officially been reported. However, during the colonial era, livestock depredation by dholes where frequently reported and make this animal be categorized as harmful animal or harmful vermin, hence, killing this animal was permitted under Game Hunting Ordinance and Regulation 1931 [34]. Livestock depredation by dholes was considerably the consequence of rapidly shrinking food supply following the human colonization of their habitat. Nowadays, based on our interview with local people who live surrounding BNP, the dhole's depredation on livestock was still occurred within the park, although it was very rare. The intensive guarding effort was likely to be a factor that reduced livestock predation in BNP [77] as has also been reported to be effective to reduce livestock depredation in India [106]. However, the occurrence of herding activities in the protected areas will enhance the potency of conflict which leads to illegal extermination by the farmers as reported to occur in Bhutan [45, 47] and Nepal [50]. Unjustified extermination has been proved to be the cause of dramatic decline on dholes population for a decade [50].

9. LEGAL STATUS OF DHOLE

Once a species has a legal status, its population become the object of law and all of treatments regarded to the population including the utilization, protection, management (e.g., hunting, ecotourism, and breeding) and conservation are regulated by the law [57]. Law is an instrument of policy and a means by which goals and values can be pursued [107], and it could translate policy position into legally enforceable obligations and rights, by threat of sanctions [108]. Protected status by law has proven to be succeed in shielding many species from the brink of extinction and improving the ability of those species to recovery over time [109]. Therefore, law can play an important role in achieving management and conservation goals.

To protect the dhole's population from extinction, the dholes are declared as protected species in the most of their range's countries in Asia (Table 2). Most of the regulations stated that law prohibits all of hunting activities on dholes. In India, permission is required to kill any individual of dhole unless in self-defense or if an individual is a man killer [64]. The dholes received protected status in Russian Federation in 1974 and listed as endangered species in Red Data Book of the Russian Federation (RDBRF), which in that time was under Soviet Law [64]. In Indonesia, the dhole received protected status through Presidential Decree No. 43 in 1978 about the endorsement of CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) Appendix 2 parts. Further, the Government of Republic Indonesia also issued Act No. 5 in 1990 with respect to the law on the conservation of biodiversity and ecosystems, Government Regulation of

the Republic of Indonesia No. 7 in 1999 with respect to the law on the preservation of flora and fauna, in which dhole was mentioned in the appendix point 13, Regulation of the Minister of Environment and Forestry No. P106 in 2018 with respect to the law second change of Regulation of the Minister of Environment and Forestry No. P20 in 2018 with respect to the law on the protected flora and fauna, in which dhole was mentioned in the appendix point 12. Nevertheless, despite the conservation status of this species is relatively high in the most of their range's countries, the conservation measures taken specifically focused on this species have never been reported [64].

The law is very dependent on the ability of the institution or agency or personnel who enforce it, so its functionality is very dependent on the behavior of the enforcer [108]. The effectiveness of the wildlife law is often influenced by non-juridical factors (e.g., political, social, economic, cultural, religious, corruption, or geographical factors) that affect the performance of law enforcement actors [57, 108-110]. In developing countries such as Indonesia, resource constraints have become a major issue that limits the government's ability to enforce the law, so that direct and indirect disturbances to protected species populations still occur. For example, in BNP, livestock grazing has occurred on a large scale and has caused occupancy shifts for almost all native mammal species, including carnivorous species such as the dhole and leopard [111]. As a generalist and opportunist predator, dholes sometimes also preyed on livestock [112], and when that happened, livestock owner secretly looked for active dhole's den and burned it. If this happens during the denning season, it is likely that the dholes will lose their offspring born in that year [113] and have a negative impact on the dhole's population dynamics in BNP. That case showed that weak control systems and lack of law enforcement can create jeopardize conditions for protected species and have the potential to reduce their long-term survival. Rowcliffe et al (2004) found that the effectiveness of species protection laws could be increased by increasing the chances of detecting violations of the law, rather than increasing penalties.

10. DISCUSSION

Based on above information, globally, there are several facts which can be pinpointed in dhole's conservation and management: 1) the important roles of dhole as an apex predator in maintaining ecosystem health cannot be denied, 2) the dholes population status in most of their range is poorly known but it is estimated to decline following the diminishing of their natural habitat, 3) the legal status of dhole's conservation are available in the most of their range, and 4) the management action which especially focused on dhole have never been reported. In Indonesia, all of the conservation actions must be based on the regulation. However, most of the regulation do does not have specific guidance for the actions, so that for the implementation it still needs technical guidance which formally issued as government regulation. For plant and animal preservation, Indonesian government issued Government Regulation of Republic Indonesia No. 7 in 1999 on the law on the preservation of flora and fauna. In this regulation, there are three steps that must be conducted to preserve a species: 1) the determination and classification of protected and unprotected, 2) management of the species and their habitats, 3) maintenance and breeding. According to the regulation, the dhole is classified as protected species, so that this species must be preserved. This means that first step for this species preservation has already achieved. Therefore, the second and subsequent steps should be conducted.

Based on the regulation, the preservation can be conducted inside (in situ) and beyond (ex situ) its natural habitat. However, this step has not been conducted in the most of dhole's population in Indonesia, particularly in Java. Until nowadays, not only management actions are missing but also the basic data concerning dholes ecology are absent in the most of the dholes natural range in Indonesia. BNP is the only protected area in Java which has the actual information concerning the biology and ecology of dholes [35, 77-79]. Although BNP experienced high anthropogenic pressure [58], the healthy population of dhole has been found in this park. The occurrence 2 of 4 packs which successfully breed in the park indicated that BNP one of important habitat for dhole's survival in Java [35]. This means that the opportunity for in situ conservation for dhole is still available in BNP, although the occurrence of anthropogenic activities within this park still become the major threat for the dholes long-term survival [77]. Therefore, immediate actions to manage the anthropogenic activities in the national park are necessary to be conducted.

Captive breeding is a common form of ex-situ conservation and ideally used in proactive rather than reactive manner, and preferably always in conjunction within situ conservation actions [114]. Ex-situ conservation technique is mostly applied to the species which has one or several of characteristics including endangered species, species has local important value, species of ethnobotanical interest, species of interest for restoration of local ecosystems, symbolic local species, taxonomically isolated species, and monotypic or oligotrophic genera [115]. The dholes are monotypic endangered species; thus, the ex-situ conservation of this species is necessary to be conducted. Captive breeding is useful for managing genetic diversity and serve as genetic reservoirs which will be needed for reintroduction, restocking or genetic exchange [114].

Dhole is known to breed in Beijing, Winnipeg, Dresden, Novosibirsk, Chennai (Madras), Hodenhagen, Safari Park Beekse Bergen, Magdeburg, and Howletts [64]. At the end of 2008, 675 individuals were listed in the studbook of which 299 individuals are alive, and 66% of the living captive population were captivated in Europe [90]. Cuon alpinus javanicus, a sub-species from Java, have been captivated in Europe since 19th century including Amsterdam (1855), Frankfurt (1861), London (1875), and Rotterdam (1869), and became more widespread at the beginning of 20th century including Berlin (1905), Cologne (1906), Wroclaw (1908) and Halle (1910) [90]. In Indonesia, unfortunately, there is no single species which is captivated through zoo as well as captive breeding. For long-term actions, the government should start to develop a plan to use ex-situ techniques as support in situ conservation of this species. Moreover, the condition of the populations which frequently have direct interaction with human activities will make this species vulnerable to local extinction, mainly due to the conflict and diseases and pathogens those particularly transmitted by feral and/ or domesticated dog (mange, canine distemper, parvovirus and rabies) [64].

The disease outbreak has been proved to be one of major causes of local extirpation of wild canid as reported to happen on African wild dog in Serengeti National Park Tanzania [116, 117], Masai Mara Kenya [118] and Mkomazi Game Reserve Tanzania [119]. The highly social canid such as dholes and African wild dogs in a small population have a high risk to suffer local extinction because of their intense interaction among the packs member which increase the potential for disease transmission [117]. Unfortunately, most the actions to solve disease problem were conducted as reactive rather than proactive effort when the disease has already widespread in the population, so that the management faced many difficulties (e.g., financial, technical and logistic). If the disease problem occurred in the small, fragmented population of the dholes in Java, then local extinction will become inevitable result. Therefore, the proactive approach should be conducted to determine the management options which should be applied to mitigate the problems.

11. CONCLUSION

Ensuring the availability of baseline data is the main requirement that absolutely must be fulfilled to determine the appropriate management actions for the dhole's conservation. However, missing data is still to be a common phenomenon in the most of dhole's natural range, particularly in Indonesia. Therefore, the managers must strive to make management decisions objectively and scientifically using the best available information, although management options are often limited by non-biological factors such as social, political, cultural, or financial availability, or a combination of these factors [120]. Gathering scientific data related to the dhole's conservation by the multidisciplinary team will benefit to the management in resolving the problem arises during the management process. The availability of adequate ecological data will also be useful for increasing public understanding in the importance of dhole conservation and attracting public sympathy, thus they become more tolerant to the existence of this species.

AUTHORS' CONTRIBUTIONS

All authors contributed in writing this manuscript. Sandy Nurvianto did most of the research and writing work. Muhammad Ali Imron and Sven Herzog were involved in making research designs, designing writing systematics and supervising research work. All authors discussed the results and provided comments on the manuscript. Once approved by all authors, the manuscript was submitted to the publisher.

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