



Environmental impact assessment for the conservation of terrestrial mammals at a granite quarry site at Lolobo, Côte d'Ivoire

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Abstract

Environmental impact studies are becoming a necessity for projects to guarantee sustainable development. This work aims to improve knowledge on the contribution of environmental impact studies for the conservation of mammalian fauna and its habitat at the level of the granite quarry of Lolobo, central Côte d'Ivoire. The data collection took place from 05 to 28 December 2019. It consisted, on the one hand, in carrying out surveys with the village populations and members of the quarry staff. In addition, reconnaissance marches were carried out in the vicinity of the quarry. The application of these methods made it possible to observe before the exploitation phase, 19 species distributed in 6 orders were present on the Lolobo quarry site. During the exploitation phase, 10 species distributed in 5 orders were present on the quarry site. Our survey results indicate the existence of three habitat types prior to the exploitation of the quarry, while five habitat types were identified during the exploitation. Five types of nuisance on the quarry including noise, aqueous discharges, dust emissions, vibrations and exhaust gases without forgetting the international route (Yamoussoukro-Bouaké) due to the movement of transport vehicles have been identified. We recommend other studies taking into account other wildlife taxa, plant diversity but also environmental monitoring at the level of granite quarries to guarantee the conservation of biodiversity.

Keywords: Environmental impact; Conservation; Mammals; Species richness; Granite quarry; Côte d'Ivoire

1. Introduction

Environmental degradation is a growing concern for the scientific community [1, 2]. The disappearance of animals and their habitats does not guarantee the sustainability of ecosystem services [3]. Environmental protection is a global challenge that involves all socio-economic and ecological stakeholders in order to ensure sustainable development. It is in this context that environmental and social impact assessments (ESIAs) have been established for all development projects. ESIAs are considered as a set of interdisciplinary procedures taking place in several stages to ensure that environmental and social considerations are taken into account in decisions concerning development projects [2, 4]. Among these projects, quarrying activities consisting of granite exploitation occupy a prominent place for the establishment of road infrastructure [5]. Unfortunately, the economic interests linked to the exploitation of granite are often accompanied by significant undesirable impacts on the environment [5, 6]. In Côte d'Ivoire, despite awareness of the importance of environmental impact assessments (EIAs), the impacts of granite quarrying activities on wildlife and their habitats remain insufficiently known [5, 7]. According to Ahon (2015) [3, 8], the state of wildlife and its habitat are also poorly understood at different phases of quarrying activities in different areas of the country, such as the locality of Lolobo in the Yamoussoukro department. However, knowledge of wildlife diversity and its preferred habitat are

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crucial in decision-making regarding environmental protection and conservation of animal biodiversity [1, 3]. Medium and large mammalian fauna in particular are intolerant of human interference and constitute good indicators of the health of habitats. The general objective of this work is to contribute to the understanding of the role of EIAs in the conservation of mammalian fauna and their habitats at the quarry level. More specifically, it concerns ; (i) determine the diversity of mammal species and their habitats before and during the exploitation phase of the Lolobo quarry (ii) identify the impacts linked to the exploitation of the quarry on mammalian fauna and its habitat.

2. Methodology

2.1. Study area

The study site is located in the Autonomous District of Yamoussoukro, precisely in the department of Attiéguakro, in the sub-prefecture of Lolobo, which is in the center of Côte d'Ivoire. The locality of Lolobo is located in the 29N UTM zone between 240000 and 250000 East longitudes and between 760000 and 780000 North latitudes (Figure 1). The quarry site is located more precisely 5 km from the village of Lolobo and approximately 6 km from the village of N'Dênou, on the Yamoussoukro-Bouaké axis. The opening and exploitation area of the quarry covers an area of 100 ha. The main activity of the Lolobo quarry operation is the extraction of aggregates for use in the construction of the Yamoussoukro-Bouaké highway.

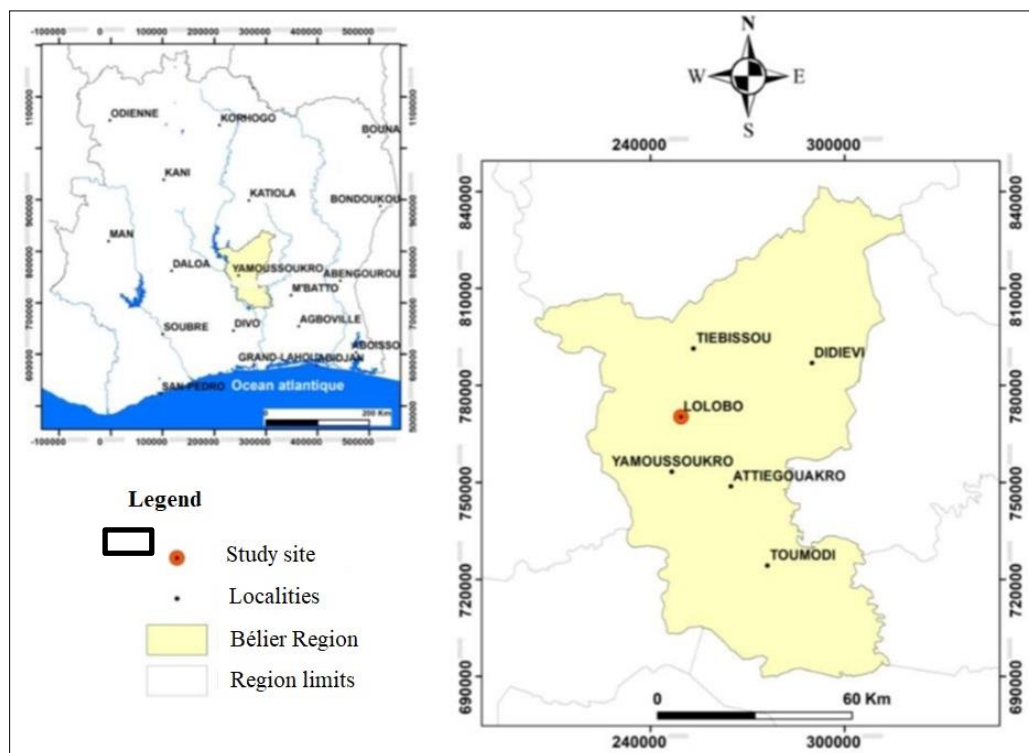


Figure 1 Geographical location of the study area

2.2. Data collection methods

Three main data collection methods were combined during this study to optimize our results. These are surveys of local populations in the sub-prefecture of Lolobo, reconnaissance walks and documentary research [3, 8].

2.3. Documentary research

The literature search consisted of collecting existing documentation on the study area and similar studies before collecting data on the quarry site and during reconnaissance walks during wildlife surveys [9]. This search also included journals, study reports and research works on wildlife conservation.

2.4. Surveys of local populations

These surveys were carried out two weeks from 8 a.m. to 5 p.m. after obtaining authorization from the General Management of the SINTRAM-CI company and the chiefdom of the villages targeted for the study. The choice of the study population was based on people aged 20 and over, composed of young people and old people (men and women) living in the villages (Lolobo, N'Dêdo and N'Dênou) closest to the Lolobo granite quarry. In addition to this criterion, we ensured that the people to be surveyed in the villages had resided in these localities for years and that they had a good knowledge of the wildlife. In addition to people from the aforementioned villages, members of the quarry staff were also surveyed. A minimum number of 20 people to be interviewed was targeted in each village to take into account the target age group and the size of the village population. This method consisted on the one hand in collecting from these populations information relating to the diversity of mammal species and their habitats in the quarry area before and during the exploitation phase and on the other hand in identifying the impacts and risks linked to the exploitation (the types of nuisances) of the quarry on the mammalian fauna. The questionnaire previously developed for this purpose was submitted individually to the people surveyed.

2.5. Reconnaissance walk

The reconnaissance walk technique or reconnaissance walk (recce) consists of walking slowly and silently with a speed of approximately 05 to 10 m/min using the areas of least resistance, preferably tracks present in the environment in order to collect data relating to the presence of mammals and human activities [10]. This sampling technique has the advantage of covering large areas in a short time. When an animal or an indication of presence is encountered, the following observations are noted: the type of indication, the geographical coordinates, the number of indications or animals counted and the type of habitat. During the inventory, the animal species were identified based on our knowledge and the help of the local guide. During the reconnaissance walk, the types of human activities including the types of nuisances (noise, dust emissions) from the different activities of the quarry were noted in order to identify the impacts and risks on mammals and their habitats [11].

2.6. Data analysis

The identification of animal species was done with the guide to African mammals [12]. Sorting and synthesis were done in Excel to determine the diversity or list of mammal species present on the study site. In addition, the geographical coordinates of the observation points of the indices were used to map the distribution of the animal presence indices in QGIS software Version (3.10.6). PAST software version 3.25 was used to determine the correlation between the number of animal presence indices observed and the distance between these indices from the quarry.

3. Results

3.1. Specific richness of mammals and their habitats before quarry exploitation through the perceptions of the population

Table 1 List of large and medium-sized mammals with their habitats before the exploitation phase of the Lolobo quarry according to the surveys

Order	Scientific name	Type of habitat	Big	AVERAGE
Primates	<i>Cercopithecus aethiops sabaesus</i>	Lowlands		X
	<i>Erythrocebus patas</i>	Forest		X
Artiodactyls	<i>Alcelaphus buselaphus</i>	Savannah	X	
	<i>Syncerus Caffer nanus</i>	Forest	X	
	<i>Kobus kob kob</i>	Savannah	X	
	<i>Tragelaphus scriptus</i>	Forest	X	
	<i>Kobus ellipsiprymnus</i>	Forest	X	X
Rodents	<i>Atherurus africanus</i>	Forest		X
	<i>Hystrix cristata</i>	Savannah		X
	<i>Protoxerus stangeri</i>	Forest		X

	<i>Thryonomys swinderianus</i>	Savannah		X
	<i>Cricetomys gambianus</i>	Savannah		X
	<i>Paraxerus poenis</i>	Forest		X
Carnivores	<i>Crosssarchus obscurus</i>	Lowlands		X
	<i>Civettictis civetta</i>	Forest		X
	<i>Xerus erythropus</i>	Savannah		X
	<i>Herpestes sanguineus</i>	Lowlands		X
Lagomorphs	<i>Lepus crawshayi</i>	Forest		X
Cetartiodactyls	<i>Cephalophus monticola</i>	Forest		X

Population surveys confirmed that several mammal species existed before the quarry operation. Among them, there are rare species and abundant species. The abundant species are composed of bushbuck, Maxwell's duiker, African civet, hare, grasscutter, African squirrel and porcupine. The rare species are composed of primates, waterbuck and hartebeest. In total, 19 species of large and medium-sized mammals divided into 18 genera and grouped into six orders were identified during the surveys. The surveys show that there were 03 types of habitats for mammalian fauna before the quarry operation phase : forest, lowland and savanna. The most representative order of mammals is that of Rodents with 06 species, three of which are observed in savannah and 3 in forest habitats. The orders of Cetartiodactyls and Lagomorphs are the least represented with one species for each concerning the observations made in the forest. Before the exploitation phase of the Lolobo quarry, the specific richness of medium-sized mammals and that of large mammals are similar with respectively 10 and 09 species present in the area of the villages surveyed. The most frequently cited order is the order of Rodentia representing 32% of all the animals cited. The lowest frequencies are those of Lagomorphs with (5%) and Cetartiodactyls (5%) (Table 1).

3.2. Specific richness of mammals and their habitats during quarry exploitation through population perceptions and pedestrian surveys

A total of 26 signs of the presence of animal species were recorded. The types of signs observed were: droppings (03), food traces (12), vocalizations (08), and footprints (03). Figure 2 shows images of some signs.

The survey results show that, since the quarry was established, many species have disappeared in the Lolobo sub-prefecture. These include the Callitriches monkey, the Harnessed bushbuck, and the hare.



Figure 2a *Thryonomys swinderianus* droppings



Figure 1b Food remains of *Thryonomys swinderianus*

Figure 2 Some signs of animal presence at the study site

No direct observation of wild mammals was made during the recce. These observations indicate that the signs of animal presence are more abundant in the fields (10 signs) than in other types of habitats. The lowland represents the habitat where fewer signs of animals were observed (2 signs). During the recce, a total of seven (07) species of medium-sized mammals were identified in five different types of habitat (field, lowland, forest, fallow and savannah) while nine (9) species of medium-sized mammals and one (01) species of large mammals were cited during the surveys. All of these mammals were divided into nine (09) genera and four (05) orders. Rodents are the most representative with four (04) species observed in the fields, forest and lowland. The least represented orders are the Lagomorphs with one species

(01) observed in the fields, the Primates with one species (01) observed in the fields and the Artiodactyls with only one (01) species observed in the forest. The medium-sized mammals represented by nine (09) species have a relatively greater specific richness than that of the large mammals represented by only one (01) species each (Table 2).

Table 2 List of medium and large mammals during the exploitation of the Lolobo quarry according to the surveys

Order	Scientific name	Type of Habitat	Recce	Surveys
Artiodactyls	<i>Tragelaphus scriptus</i>	Forest		X
Lagomorphs	<i>Lepus crawshayi</i>	Field	X	X
Rodents	<i>Atherurus africanus</i>	Forest	X	X
	<i>Cricetomys gambianus</i>	Forest	X	X
	<i>Paraxerus poenis</i>	Lowlands	X	X
	<i>Xerus erythropus</i>	Field	X	
Carnivores	<i>Crossarchus obscurus</i>	Savannah	X	X
	<i>Herpestes sanguineus</i>	Jachère	X	X
Primates	<i>Cercopithecus aethiops sabaues</i>	Field	X	X

3.3. Impacts of quarry exploitation on mammalian fauna and its habitat

Observations carried out on the quarry made it possible to identify five different types of nuisances generated during the quarry exploitation activities. The handling of materials causes the emission of dust. The discharge of quarry water into the hydrographic network pollutes the watercourses essential to the life of mammals. The use of thermal engine machinery and equipment pollutes the atmosphere. The installation of treatment plants, movement of machinery and trucks emit deafening noises. Shots and explosion of dynamite (Table 3).

Table 3 Different types of nuisances from the quarry on mammalian fauna

Types of nuisances	Sources
Dust emission	Materials Handling (Extraction)
Aqueous discharges	Discharge of quarry water into the hydrographic network
Air pollutants (exhaust gases)	Use of thermal engine-powered machinery and equipment
Noise (Noise Pollution)	Processing and traffic installation for machinery and trucks
Vibration	Shots and dynamite explosion

3.4. Impact of the quarry on the distribution of mammals in the vicinity of the site

Mammal presence signs were observed at different locations in the quarry area. More than 77% of mammal presence signs were observed within 2 km of the quarry. Outside the quarry and within a radius of 4 km, 23% of mammal presence signs were observed. A few hundred meters (400-900 m) from the highway, no mammal signs were observed. Figure 3 shows the evolution of the abundance of mammal presence signs at the study site in relation to their distance from the quarry. The study results indicate that between 0 and 1200 m from the quarry a high proportion of mammal presence signs is observed (77% of the total signs) and the number of signs observed increases between this distance interval. Beyond 1200 m up to the highway between the Yamoussoukro and Bouaké axis, a low proportion of indices was observed with 23% of the total indices of mammal presence detected on the site (Figure 3).

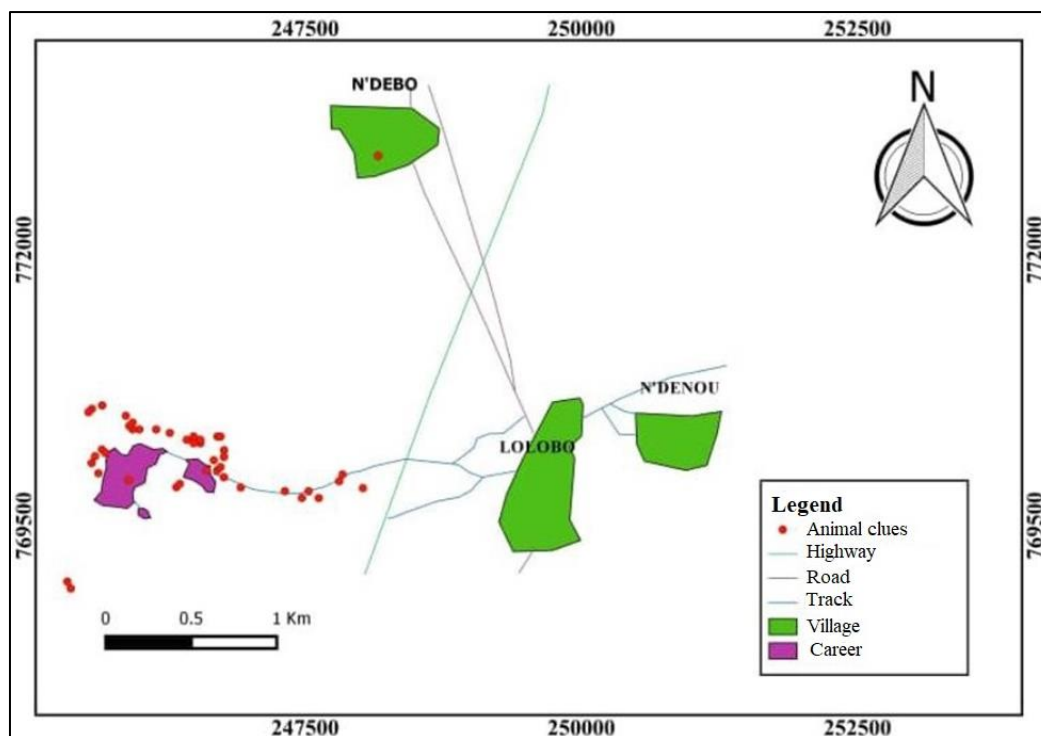


Figure 3 Distribution of mammal presence indices around the Lolobo granite quarry

The coefficient of determination ($R^2 = 0.626$) indicates a positive relationship between the distance to the quarry variable and the number of mammal presence indices variable. The number of animal presence indices and the distances of animal presence indices around the quarry are strongly linked because the R^2 value obtained tends towards 1 (Figure 4).

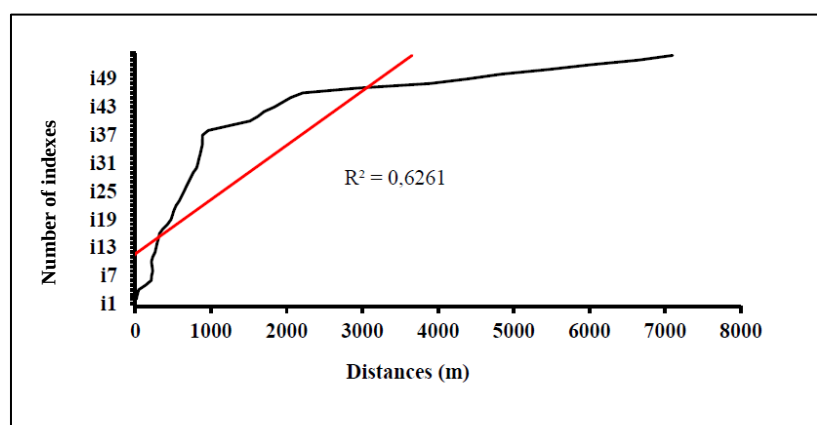


Figure 4 Evolution curve of mammal presence indices around the Lolobo granite quarry

3.5. Impacts of quarry activities on the natural environment habitat

The Lolobo granite quarry operation was carried out on wooded land, including fields, forests, lowlands, savannah and fallow land, which continue to be cleared and uprooted. Mineral oils, used greases, flammable liquids, including organic solvents, hydrocarbon-contaminated water, sedimentation or tank decantation sludge containing hydrocarbons and petroleum product residues were observed on the site. Dust, aqueous discharges from households and smoke from vehicle exhaust fumes were observed on plants and soil in the vicinity of the quarry site. Early fall of tomato, coffee and cocoa flowers was observed in the vicinity of the quarry site (Figure 5).



Figure 5a Fallow land flooded with wastewater



Figure 5a Cassava field covered in dust

Figure 5 Some images of the state of the habitat in the vicinity of the quarry site

4. Discussion

Nineteen (19) mammal species were identified before the quarry exploitation phase while during the exploitation phase only ten (10) mammal species were identified. Among the species identified during the exploitation phase, seven (07) species were confirmed during the recce. This difference in the diversity of mammal species could be explained by the possible influence of the intensity of anthropogenic activities that took place between the period before exploitation and during the exploitation of the granite quarry on the fauna. Our results are identical to those of Akpatou [7] during the environmental and social impact study of the mining site in Yaourè who observed twenty-five (25) species, grouped into six (06) orders in the north of the city of Yamoussoukro. Indeed, the two unprotected environments being located in the same region, they were subjected to similar anthropogenic pressures during quarry activities. The seven (07) species of mammals identified by the recce are grouped into two (02) orders, which are Rodents and Carnivores. This richness of mammals recorded during the reconnaissance walks is identical to the results of Chenot [13] in the ecological rehabilitation of ecosystems degraded by the exploitation of quarries in Avignon in France with ten (10) species grouped into three (3) orders. These results could be explained by the fact that the two sites are located in different countries but disturbed by quarry activities. However, the number of species observed during our study is lower than that observed by other authors in Ivory Coast. For example, Yaokokore-Beibro [14] in the Badénou classified forest in Korhogo, observed 45 species grouped into nine (09) orders while Bohoussou [15] observed 31 species, grouped into six (06) orders in the forest relics within an agro-industrial concession in the southwest of Côte d'Ivoire. The reduction of animal species in the vicinity of the quarry site could be explained by the degradation of their habitats and the human presence in these environments. The work carried out made it possible to identify five types of nuisances, including noise, aqueous discharges, dust emissions, vibrations and exhaust gases. Each of these types of nuisances could have one or more specific impacts on mammalian fauna. For example, noise could cause animals to flee, stress and sleep disorders in the short term given their sensitivity to this type of environmental disturbance [7]. Our results are similar to those of Dutilleux [16] in a study report on road noise and wildlife in France. This author observed the noise damage generated by road transport and human activities on wildlife. The results of our study also corroborate those of Calugaru [17] in lignite mining and landscape rehabilitation in the Oltenia mining region in Romania. This author demonstrated the impacts of quarrying on the environment through the atmosphere, fauna and flora. Observing signs of the presence of mammals around the quarry shows that some animal species would be relatively insensitive to the disturbances caused by quarrying activities [15, 18]. Our results are identical to the work of Colas [16, 19] who studied the effects of the project on health at the Keramborn quarry in Dirinon, France. Regarding the habitat, three types were observable at the study site according to the people surveyed : forest, lowland and savannah. However, during the exploitation phase, five habitat types were observed : forest, savannah, field, fallow, savannah and lowland. This in fact shows that natural environments are heavily disturbed by quarrying activities [13, 14]. The fall of tomato, cocoa and coffee flowers during the flowering period and dust on plants would be due to ground vibrations, dust emissions from machinery and chemical spills on the ground. These results corroborate with those of Daho [18] who worked on the effects of extraction of massive rocks on the environment. These same results corroborate with those of Lansart (2008) [11] in the Evaluation of the environmental impacts of quarries in France. This author has shown the impacts linked to the extraction of granites on flora.

5. Conclusion

At the end of this study, we note that before the exploitation phase 19 species of mammals divided into six (06) orders were present on the current site of the Lolobo quarry. During the exploitation phase ten (10) species divided into five (05) orders are present on the current site of the quarry. The results of the surveys indicate the existence of three types of habitats (forest, lowland and savannah) before the exploitation of the quarry while five types of habitats were identified during the exploitation (field, forest, fallow savannah and lowland). With regard to impacts and risks, five types of nuisances from the quarry including noise, aqueous discharges, dust emissions, vibrations and exhaust gases were identified without forgetting the nuisances of the international route (Yamoussoukro-Bouaké) mainly due to the circulation of transport vehicles. The granite quarry of the Lolobo sub-prefecture still has a relatively significant faunal richness. This study allowed to make some indirect observations of the animals living in the sub-prefecture. The recce made it possible to confirm the presence of seven (07) species of medium-sized mammals. The brown mongoose, and the red mongoose, marsh mongoose of the order Canivores as well as the wood squirrel, the palm rat, the giant rat of Gambia and the cane rats of the order Rodents. The rate of encounter of mammals around the quarry is higher than when moving away from the granite quarry towards the highway. Mammals are threatened by the various activities of the quarry.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that there are no conflicts of interest for this article.

Author contributions

KOUAKOU YAO CELESTIN is the initiator of the project. ASSI YAPI CONSTANTIN and BAMBA KRAMOKO performed the data processing, statistical analysis, and manuscript writing. The other co-authors contributed to reviewing and improving the article.

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