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Awareness and nutrient composition of duckweed (*Lemna spp*) as a potential feed for ruminants

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Abstract

The availability of feed and feedstuff for livestock is a perennial challenge to livestock productivity in Nigeria. Similarly, the high cost and competition between humans and animals for conventional feed ingredients necessitated the search for alternative feed resources. Duckweed is an emerging non-conventional aquatic feed resource. However, inadequate awareness about its nutrient potential has limited its utilization as livestock feed. Therefore, this study was carried out to access the awareness and perception of fish pond owners about duckweed plant and its potential *as feed for ruminants* in Ibadan/Ibarapa zone of Oyo State. *A structured questionnaire was administered to elicit information on the socioeconomic characteristics of fish farmers, the availability of duckweed in earthen fish ponds, perception of its use and nutrient potential.* The data collected were analysed with descriptive statistics. *The study revealed that a majority (62.5%) of the fish farmers were at* their active and economically productive age. *A higher percentage (62.5%) of the farmers had tertiary education while an* average of 31.25% had $3 \geq 20$ years of fish farming experience. *Virtually all (93.7%) of the fish ponds had duckweed (Lemna spp) growing on the water surfaces, which the fish pond owners (93.75%) strongly regarded as a nuisance. About 56.25% of the fish farmers disagree that duckweed can be used as feed while 43.75% of the respondent were not sure if it can be used as feed. However, all (100%) of the respondents have never used duckweed to feed livestock and 81.2% of them had no awareness of its uses. The proximate composition of the duckweed in the study area showed a mean value of 10.50%CP, 10.55%CF, 6.22% EE and 13.09% ash. In conclusion, duckweed (*Lemna spp) was available in virtually all ponds considered in Ibadan/Ibarapa zone of Oyo State but the perception of the fish farmers revealed a lack of awareness about its feeding value. However, the appreciable nutrient content could justify the use of duckweed as a potential feed resource for livestock.

Keywords: Awareness, duckweed, fish farmers, feed resource, nutrient composition

Conscience et composition en nutriments de la lentille (*Lemna spp*) comme alimentation potentielle pour les ruminants

Résumé

La disponibilité des aliments et des aliments pour animaux pour le bétail est un défi vivace pour la productivité du bétail au Nigéria. De même, le coût élevé et la concurrence entre les humains et les animaux pour les ingrédients d'alimentation conventionnels ont nécessité la recherche de ressources d'alimentation alternatives. La lentille est une ressource d'alimentation aquatique non conventionnelle émergente. Cependant, une conscience inadéquate de son potentiel nutritif a limité son utilisation en tant qu'alimentation du

*bétail. Par conséquent, cette étude a été réalisée pour accéder à la sensibilisation et à la perception des propriétaires d'étangs de poisson sur la plante de lentille et son potentiel comme alimentation pour les ruminants dans la région d'Ibadan / Ibarapa de l'État d'Oyo. Un questionnaire structuré a été administré pour provoquer des informations sur les caractéristiques socioéconomiques des pisciculteurs, la disponibilité de la lentille dans les étangs de poisson en terre, la perception de son utilisation et de son potentiel nutritif. Les données recueillies ont été analysées avec des statistiques descriptives. L'étude a révélé qu'une majorité (62,5%) des piscicoles avaient leur âge actif et économiquement productif. Un pourcentage plus élevé (62,5%) des agriculteurs avait un enseignement supérieur tandis qu'une moyenne de 31,25% avait 3 ≥20 ans d'expérience dans les pisciculture*s. *Pratiquement tous (93,7%) des étangs de poisson avaient une alliance (Lemna spp) poussant sur les surfaces d'eau, que les propriétaires de l'étang de poisson (93,75%) considéraient fortement comme une nuisance. Environ 56,25% des pisciculteurs ne sont pas d'accord pour dire que la lentille peut être utilisée comme alimentation tandis que 43,75% des répondants ne savaient pas s'il peut être utilisé comme alimentation. Cependant, tous (100%) des répondants n'ont jamais utilisé de lentille pour nourrir le bétail et 81,2% d'entre eux n'avaient aucune prise de conscience de ses utilisations. La composition immédiate de la lentille dans la zone d'étude a montré une valeur moyenne de 10,50% CP, 10,55% CF, 6,22% EE et 13,09% de cendres. En conclusion, Duckweed (Lemna spp) était disponible dans pratiquement tous les étangs considérés dans la zone d'Ibadan / Ibarapa de l'État d'Oyo, mais la perception des pisciculteurs a révélé un manque de conscience de sa valeur d'alimentation. Cependant, la teneur en nutriments appréciables pourrait justifier l'utilisation de la lentille comme une ressource d'alimentation potentielle pour le bétail.*

Mots-clés: sensibilisation, lentilles, les pisciculteurs, les ressources alimentaires, la composition des nutriments

الوعى و التكوين الغذاء لعشب البط كعلف محتمل للحيوانات المجترة

نبذة مختصرة

يمثل توافر الأعلاف والأعلاف للماشية تحديًا دائمًا لإنتاج الثروة الحيوانية في نيجيريا. وبالمثل، فإن التكلفة العالية والمنافسة بين الإنسان والحيوان على مكونات الأعلاف التقليدية استلزم البحث عن موارد أعلاف بديلة. طحل بالبط هو مصدر علفمائ يغير تقليد يناشئ. ومع ذلك، فقد أدى عدم كفاية الوعيب إمكان ياتها الغذائية إلى الحد من استخدامها كعلف للماشية .لذلك، تم إجراء هذه الدراسة للوصول إلى وعيو إدراك أصحاب أحواض الأسماك حول نبات الطحل بالبط وإمكان اتهك غذاء للمجترات في منطقة إبادن / إيبارابا في ولاية أويو . تم إجراء استبيان منظمل لحصول على معلومات حول الخصائص الاجتماعية والاقتصادية لمزارعي الأسماك، ومدى توافر الطحل بالبطي في أحواض الأسماك الأرضية، وتصور استخدامه وإمكاناته الغذائية. تم تحليل البيانات التيتم جمعها باستخدام الإحصاء الوصفي، حيث كشفت الدراسة أنغالبية (62.5%) من مزارعي الأسماك كانوا في سن نشطة ومنتجة اقتصاديًا، ونسبة أعلى (62.5%) من المزارعين حصلوا على تعليم جامعي بين ما كان متوسط (31.25%) منهم حاصلين على تعليم جامعي . 3 إلى 20 عامًا منا لخبرة في الاستزراع السمكي .تقريبًا (33.7%) من أحواض الأسماك كان ينمو فيها طحل ببط (Lemna spp)على سطح المياه، والذي يعتبره أصحاب أحواض الأسماك (93.75%) مصدر إزعاج. لا يوافق حوالي (56.25%) من مزارعي الأسماك على إمكانية استخدام طحل بالبط كعلف بين ما لم يكن (43.75%) من المستجيبين متأكدين مما إذا كان يمكن استخدامه كعلف. ومع ذلك، فإن جميع المستجيبين (100%) لم يستخدموا أبدًا عش بالبطل تغذية الماشية و (81.2%) منهم ليسلديهم وعيب استخداماته. أظهر التركيب التقريبي لعشب البط في منطقة الدراسة قيمة وسطية قدرها10.50 ٪ CP و10.55 ٪ CF و6.22 ٪ EE و13.09 ٪ رماد. وفي الختام،كان طحل

بالبط(Lemna spp) متاحًا في جميع البرك تقريبًا التيتم النظر فيها في إبادن/ إيبارابا. في ولاية أويو، لكن تصور مزارعي الأسماك أظهر نقصًا في الوعيب قيمتها الغذائية، ومع ذلك، فإن المحتوى الغذائي الملحوظ يمكن أن يبرر استخدام طحل بالبط كمصدر علف محتمل للماشية.

الكلمات المفتاحية: التوعية، الطحل بالبطي، مزارعو الأسماك، مصادر الأعلاف، تركيبة المغذيات

Introduction

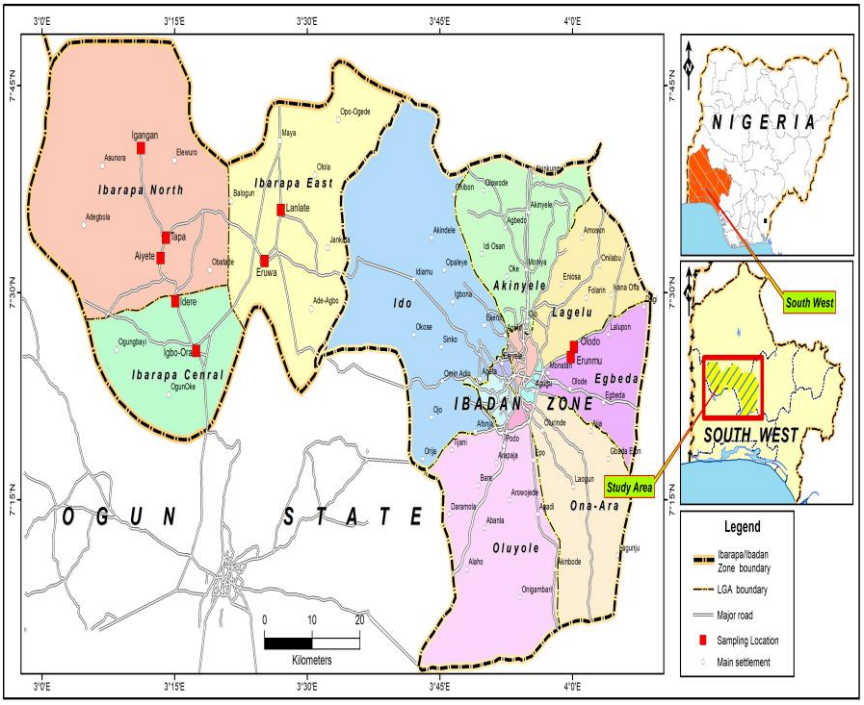
The perennial challenge of seasonal forage availability and astronomical increase in prices of feed ingredients for livestock triggered myriads of research on alternative feed for the sustenance of the livestock industry. Interestingly, the utilization of most alternative feed resources started with awareness creation via baseline surveys and scientific studies involving animal experimentation for evaluation of its nutritional potential to enhance the growth of animals. Notable examples are aquatic weeds such as water hyacinths, whose nutrient potential for livestock (Mako *et al*., 2016; Akankali and Elenwa, 2019) and their use as a forage to salvage dry season feed scarcity (Wimalarathne and Perera, 2019) has been documented. Another novel aquatic feed resource which has not received enough attention to complement conventional animal feed is duckweeds, which are free-floating plants of the family *Lemnaceae*, consisting of five genera; *Landoltia*, *Lemna, Spirodela, Wolffia* and *Wolffiella* (Tang *et al.,* 2015). Duckweeds have demonstrated the potential for a sustainable feed supply specifically because of their ability to grow rapidly (Sree *et al*., 2015) and adaptability to different aquatic environments. Duckweed species inhabit and grow well on stagnant/calm surface waters such as ponds or lakes (Ziegler *et al*., 2015) under favourable growth conditions. Duckweed is reportedly rich in proteins, fatty acids (Yan *et al*., 2013; Appenroth *et al*., 2017) and minerals (Mwale and Gwaze, 2013) though the quality and contents of these nutrients depend on the medium of growth and duckweed species. Unlike the wide acceptability of water hyacinth as ruminant feed, duckweed has not been adequately explored in ruminant nutrition (van der Spiegel *et al*., 2013) despite the fact that it can be consumed in both fresh and dried forms (Babayemi *et al*., 2006; Heuze and Tran, 2015).

In Southwest Nigeria, specifically in Oyo State, duckweed species are noticeable aquatic plants frequently growing in abandoned earthen fish ponds when active fish farming has stopped or in a poorly managed fish pond. Oftentimes, it constitutes a major problem for aquaculture management as it increases the cost of fish farming because considerable efforts are made for its evacuation. On the other hand, duckweed has potential in feed formulation for fish, pigs and poultry (Gwaze and Mwale, 2015), treatment of wastewater quality and restoration of neglected ponds (Ziegler *et al*., 2017) and as biofuels (Faizal *et al*., 2021). This has resulted in its cultivation in Asian countries (Xu *et al*., 2012; Chakrabarti *et al*., 2018; Appenroth, 2019). However, duckweed production and its uses in Nigeria are limited probably because of the dearth of awareness about its potential, production know-how and nutrient composition. Consequently, a study was designed to assess the awareness and utilization of duckweed species as a potential novel feed resource for livestock in selected towns located in Ibadan/Ibarapa, Oyo State. The specific

objectives of the study are to: (1) describe the demographic and socioeconomic characteristics of fish farmers and the availability of duckweed in the study area (2) evaluate the perception of fish farmers about duckweed in fish ponds (3) identify the duckweed species in the study area and evaluate its proximate composition.

Materials and methods

The study was carried out in selected fish farms where earthen ponds were used for rearing fish at Eruwa, Igboora, Lanlate, Idere, Tapa, Ayete, Igangan, Erunmu and Olodo located in Ibadan/Ibarapa, Oyo State, Nigeria, Southwest geo-political zone (Latitude, 70.15°N and 70.55°N and Longitude, 30°E and 30.30°E). The area has a humid climate with an annual rainfall of 1,250mm. A mapping and reconnaissance survey was carried out using a Global Information System (GIS) to get familiarized with the study areas. The choice of study areas was based on the reports of Sanusi *et al*. (2016). A structured questionnaire was administered using the interview method to elicit information about the demographic and socioeconomic status of fish farmers in the study areas. Duckweeds were harvested (scooped) from the surfaces of fish ponds at the locations with a sieve of 4mm diameter mesh size. The duckweed was weighed immediately after draining to determine the moisture content and identification of the species. Identification of duckweed species was carried out at the Department of Botany, University of Ibadan.



Source: Field survey, 2020

Figure 1: Map of Ibadan/Ibarapa zone of Oyo State showing locations of the study area

Proximate and statistical analyses

The proximate component (dry matter, crude protein, ether extract, crude fibre and ash) of identified duckweeds was determined as described by AOAC (1990). Data collected on the demographic, socio-economic status and perception of the respondents were analyzed using descriptive statistics.

Results and discussion

Table 1 shows the demographic status of the fish farmers in the study areas. A larger percentage (62.5%) of the fish farmers were in the age bracket of 41 to 50 years. This suggests that the majority of the fish farmers were in the active age group required for the sustainability of fish production enterprise and this is in line with the findings of Olaoye *et al*. (2013) and Sanusi *et al*. (2016) that those actively involved in fish farming enterprise are in their early and late 50s. Ninety-three percent were male, which implies that fish farming is mainly a male business, probably associated with the energy input required to guarantee effective management of earthen pond fish production systems. This agrees with the findings of Ayeloja *et al*. (2021) that male was more involved in fish farming than females. The majority (93.5%) of the farmers were married.

About sixty-two and a half percent (62.5%) of those actively involved in fish production had tertiary education though 37.5% also had secondary education. The relatively higher percentage of those who had formal education could also guarantee better utilization of inputs and fishery resources to increase their profits. Eighty-seven and a half per cent of the respondent had between 1 to 5 household sizes. About 31.25% of the respondents had $3 \geq 20$ years of experience. This implied that the respondents in the study areas had many years of experience in the management and production of fish using an earthen pond system.

Table 1: Demographic characteristics of the respondents (n=16)

Variable	Frequency	Percentage	Mean
Age (years)			
21–30	1	6.25	
31–40	3	18.75	
41–50	10	62.5	
51–60	2	12.5	
≥ 61	0	00	
Mean			**3.81 (0.750)**
Gender			
Male	15	93.75	
Female	1	6.25	
Mean			**1.94 (0.250)**
Marital status			
Singles	1	6.25	
Married	15	93.75	
Divorced	0	00	
Widow	0	00	
Mean			**1.06 (0.250)**
Household size			
1-5	14	87.5	
6-10	1	6.3	
Above 10	1	6.3	
Mean			**1.19 (0.544)**
Fish farming experience (years)			
3-8	5	31.25	
9-14	5	31.25	
15-20	5	31.25	
Above 21	1	6.25	
Mean			**12.25 (5.893)**
Formal education			
None	0	0.0	
Primary	0	0.0	
Secondary	6	37.5	
Tertiary	10	62.5	
Mean			**1.38 (0.500)**

Source: Field survey, 2020

The result of the socioeconomic status of fish farmers and duckweed availability is presented in Table 2. A majority (68.8%) of the respondents were engaged in fish farming as a full-time job. Meanwhile, 75% of the farmers purchased the land used for fish farming while over eighty-one percent used both concrete and earthen pond systems, which aligned with the reports of Olaoye *et al*. (2013). A lower

percentage (18.8%) of the respondents who used the earthen pond alone might not be unconnected with the higher cost of acquiring land. As regards the availability of duckweed species, the majority (93.8%) of the earthen fish pond in the study area had duckweed. However, the owners of the fish pond disposed of the duckweed after evacuation from the surface of their ponds. This revealed that the farmers neither use duckweed as feed for fish nor livestock. In terms of awareness, larger percentages (81.2%) of the respondents with a mean of 1.31 in the study area were not aware of the usefulness of duckweed as feed for fish and other livestock. Nevertheless, this study further suggests a need for the creation of more awareness through adequate information about the feed resource potential of duckweed to fishery and livestock industries.

Table 2: Socioeconomic characteristics of the respondents and duckweed availability

Variable	Respondent	Percentage	Mean
Commitment to fish farming			
Full time	11	68.7	
Part-time	5	31.3	
Mean			**1.19 (0.544)**
Other enterprises combined with fish farming			
Fish farming only	3	18.8	
Fish and crop farming	9	56.2	
Fish and livestock farming	3	18.8	
Others (trading, artisan, etc.,)	1	6.2	
Mean			**1.13 (0.342)**
Land acquisition			
Gift	1	6.3	
Inheritance	3	18.8	
Purchase	12	75.0	
Mean			**1.31 (0.479)**
Type of pond			
Concrete and earthen	13	81.3	
Earthen only	3	18.7	
Mean			**1.31 (0.314)**
Availability of duckweed species in the pond			
Available	15	93.7	
Not available	1	6.3	
Mean			**1.94 (0.250)**
Uses of duckweed			
Use	0		
Discard	16		
Mean		100	**1.00 (0.00)**
Awareness about the uses of duckweed			
Aware	3	18.8	
Not aware	13	81.2	
Mean			**1.31(0.314)**

Source: Field survey, 2020

The perception of respondents about duckweed and its usefulness (Table 3) indicated that 93.75% strongly agreed that it constituted a nuisance while 6.25% were undecided. As regards whether it served as feed for livestock or fish, about forty-four percent (43.75%) of the respondents were undecided while an appreciable number (56.25%) of the respondents disagreed. A majority (56.25%) of the respondents' ditto 31.25% agreed and strongly agreed respectively, that the growth of duckweed on the surface of ponds affected production output. In the same vein, most (56.25%) of the fish farmers agreed that duckweed constituted a threat to the pond's aquatic life. However, a small percentage (6.25%) of the fish farmers strongly disagreed that duckweed impacted the growth of fish compared to 75.00% who were undecided. About 43.75% of the total respondents agreed that the growth of duckweed can be controlled, others (43.75%) disagreed and 12.50% were undecided. About 43.75% agreed that the cost of evacuating duckweed from pond surfaces is high, 12.5% disagreed and 37.5% were undecided. Approximately sixty-nine percent of the respondents were not sure if the method of disposal can lead to pollution, 25.00% disagreed while 6.25% strongly accepted that the disposal method may lead to pollution. All the fish farmers (100%) affirmed that they have never used duckweed to feed livestock. The perception of the respondents in the study area revealed that there is a dearth of awareness about the use of duckweed as feed for livestock, unlike in some Asian countries where the growing awareness has resulted in the cultivation of duckweed species on non-arable land (Appenroth *et al*., 2017; Chakrabarti *et al*., 2018; Appenroth, 2019) for both livestock and human nutrition besides other uses.

Table 3: Perception (%) of respondents about duckweed in fish ponds

Items	**SA**	**A**	**U**	**D**	**SD**
Nuisance to fish farmers	93.75	00.00	6.25	00.00	00.00
Serve as a feed	00.00	00.00	43.75	56.25	00.00
Growth affects the production output	31.25	56.25	12.50	00.00	00.00
Constitutes a threat to the pond's aquatic life	18.75	56.25	25.00	00.00	00.00
Affect the growth of fish	00.00	00.00	75.00	18.75	6.25
Growth can be controlled	00.00	43.75	12.50	43.75	00.00
The cost of evacuation is high	6.25	43.75	37.50	12.50	00.00
Method of disposal can lead to pollution	00.00	00.00	68.75	25.00	6.25
Duckweed has been used to feed livestock	00.00	00.00	00.00	100.00	00.00

Source: Field survey data, 2020

SA= Strongly agree, A= Agree, U= Undecided, D= Disagree, SD= Strongly disagree

Duckweed species found in the study areas are mainly the *Lemna* species (Table 4) of the family, Lemnaceae, based on the morphological features. This might be

attributed to where the duckweed was collected being an abandoned fish pond, where fish farming activities have been suspended or stopped for a long period.

The proximate composition of duckweed (*Lemna species*) shown in Table 4 revealed the potential of duckweed to meet the nutritional requirements of livestock. Dry matter content (4.67-12.14%) of duckweed across locations of the study affirmed its high moisture content (Mwale and Gwaze, 2013), though DM content was in the range (3-14% DM) reported by Timmerman and Hoving (2016). The crude protein (4.67 to 17.50%) content obtained from the duckweed was lower than 20-35% CP reported elsewhere (Appenroth *et al*., 2017) for duckweed species. This further confirmed that nutrient availability in the aquatic environment rapidly influences the protein content of duckweed (Leng *et al*., 1995). Except for the least CP (4.67%) of duckweed from fish ponds at Olodo, the CP levels of duckweeds from other locations are higher than the 7.0% critical levels, and relatively sufficient to promote ruminal microbial activities of ruminants. The crude fibre obtained for duckweed across the locations varied from 8.70 to 12.60%.

While the low (8.70%) crude fibre content observed in the study was similar to values reported by Du *et al*. (2009), higher CF (12.60%) content was lower than the 13.2% reported by Tavares *et al*. (2010). Ether extract (3.55-8.95%) content of duckweed (*Lemna spp*) with a mean value of 6.22% was within the fat levels of 2 to 9% reported (Olorunfemi *et al*., 2006) and higher than values of 1.95 to 2.58% ether extract for duckweed cultured in different organic media (Okwuosa *et al*., 2021). The mean value of 6.22% ether extract suggests that *Lemna spp* could be a valuable dietary energy source which may not hinder ruminal microbial activity. The range (2.25 to 24.02%) of ash levels with a mean value of 13.09% obtained for duckweeds in the study areas was higher than the ash content of 3.8% to 12.3% reported by Du *et al*. (2009) in duckweed species. Variations observed in the values of proximate composition of duckweed (*Lemna spp*) in the study areas could be attributed to the growth media nutrient content, age of the plant and exposure to light. This is in agreement with the reports of several authours (Ansal *et al*., 2010; Appenroth *et al*., 2017) that duckweeds in nutrient-rich media have the potential of being higher in nutrient contents than those of nutrient-poor media. Nonetheless, the mean crude protein (10.50%), ether extract (6.22%) and ash (13.09%) contents of duckweed (*Lemna spp*) in the study areas could complement the dietary requirements of livestock though the mean value of crude fibre (10.55%) might be below the requirement for ruminant.

Table 4: Identification and proximate composition of duckweed species

	Location of the study				
	Eruwa	Lanlate	Igboora	Igangan	Olodo
Duckweed species	*Lemna* species only	*Lemna* species and spirogyra	*Lemna* species Only	*Lemna* species only	*Lemna* species only
Nutrient (%)					
Dry matter	6.51	8.23	12.14	4.67	5.28
Crude protein	17.50	11.67	10.50	8.17	4.67
Crude fibre	10.79	10.42	12.60	10.25	8.70
Ether extract	8.95	5.43	6.02	3.55	7.15
Ash	22.83	2.25	2.28	14.07	24.02
Nitrogen free extract	39.93	70.23	68.60	63.96	55.46

Conclusion

It can be concluded that the duckweed species available in an abandoned earthen fish pond in the study areas was the *Lemna spp* with an appreciable nutrient content that could justify its use as livestock feed. However, the perception of the fish farmers revealed a lack of awareness about the potential of duckweed (*Lemna spp*) as feed for livestock. Nevertheless, the age brackets, educational levels and fish farming experience of the farmers in the study areas could be explored as an added advantage for sensitization and creation of awareness on the feed potential of duckweed for livestock. It is suggested that *in vitro* and *in vivo* studies should be conducted to assess the impact of duckweed (Lemna plant) on livestock performance.

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