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Abstract

To evaluate the growth performance of mallard ducks fed azolla as partial replacement of soybean meal, a study was carried out from April 6, 2020 to June 6, 2020 in San Ildefonso, Bulacan. A total of apparently healthy, 180 heads of 15-day-old mallard ducks (90 female and 90 male) were used in the study with 2 x 3 factorial experiment in Completely Randomized Design (CRD). Factor A was the sex of ducks while Factor B was the level of substitution. Mallard ducks with a 10% substitution level were significantly better than the 20% substitution level in terms of weight gain, feed consumption, feed conversion ratio (FCR), and ROI. Further analysis on the dressing percentage revealed that there was no significant effect on the sex of ducks, level of substitution and interactions between the two factors. The results of the study revealed that the azolla meal diets have nutritive and feeding values based on the proximate analysis being conducted. It was concluded that Azolla at 10% level in the diet improved gain in body weight, feed consumption and FCR especially on both sexes of ducks. Using mash rations with the inclusion of Azolla at 10% level could be used as substitutes for soya bean meal on mallard duck diet. All these facts suggested further study on other level of substitutions of Azolla to soybean meal to gain additional knowledge about its effects, study focusing on only one sex of mallard duck to further analyze the economics and tried to other animals, such as swine and ruminants, as an alternative source of protein with 10% level of substitution, and educate and encourage farmers through training and seminars to raise and produce azolla in order to make it readily available to animals, especially during lean months, as arable areas for feed crops are declining due to the higher populations of both humans and animals.

Keywords: *azolla, mallard duck, soybean meal, mash ration*

Introduction

In the Philippines, duck production is a lucrative enterprise. It is a multi-billion-dollar industry with a diverse group of stakeholders, including duck farmers, egg vendors, feed mills, hatcheries, processors, and rice farmers, who gain both direct and indirect benefits from the business. As of 31 March 2022, the country's total production of ducks stood at 12.54 million birds (PSA 2021).

About 31.0 percent of duck population was recorded in Central Luzon, followed by SOCCSKSARGEN with 12.3 percent share and Cagayan Valley with 10.2 percent share (PSA, 2022).

Duck production is one aspect of an integrated farming system that is considered part of sustainable agricultural development and one of the innovations that can be applied by farmer to increase the efficiency and sustainability of land use in rice field (Vipriyanti *et al.* 2021). The main stock

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used is the Pateros duck, which exhibits varied physical and production performance due to lack of organized selection and mating systems. It also shows high genetic diversity based on simple-sequence repeats markers (Magpantay *et al.* 2019). These are large, with heavy bodies, rounded heads, and wide flat bills. As with many dabbling ducks, the body is long and the tail rides high out of the water, set back to the rear.

Some of the ingredients used in mixed feeds, especially cereal grains, are in high demand for human consumption, apart from the high and fluctuating prices. There were also huge increases in the prices of some suppliers of vegetable protein. These increases in the cost of traditional raw materials have speeded up demand for alternative feed options that can replace a proportion of these items in poultry diets at lower production costs. (USDA, 2015).

Conventional animal feeds are severely in short supply. Using unconventional feed sources more effectively is essential to feeding the animals in the future. Partially bridging the feed supply gap could be non-traditional feeds. They lessen animal and human food competition, cut the price of feed, and help the body produce enough nutrients on its own (Sontakke 2014).

An important feed element is the Azolla (*Azolla pinnata*). It is a productive plant and a genus of seven species of aquatic ferns in the Salviniaceae family. It is high in proteins and mineral, fixes nitrogen and is palatable to chickens, pigs, poultry, goats, and cows, and can be grown on any closed body of water (agrifarming 2020).

Feeding ducks properly is a challenging act of balancing animal needs, production methods, productivity, local tradition and feeding costs (Mavromichalis I.2013). Hence, mash form of feeds with the inclusion of Azolla in the earlier stage of ducks was studied.

Objectives of the Study

This study aimed to determine the growth performance of ducks fed with mash ration with the inclusion of Azolla as partial replacement for soya bean meal.

Specifically, it aimed to:

1. determine the growth performance of Mallard duck;
2. identify the optimum level of Azolla leaf meal as a protein substitute;
3. evaluate the dressing percentage of Mallard duck given mash feeds with Azolla leaf meal inclusion; and
4. find out the economic viability of using Azolla leaf meal on Mallard duck production through cost and return analysis.

Materials & Methods

Locale of the Study

The experiment was carried out at Barangay Sta. Catalina Matanda, San Ildefonso, Bulacan. The area was characterized as low-level, with slightly sloppy areas, an area of 40.5 m² and a sufficient source of water due to the presence of a pond making it suitable for the production of animals.

The site was typically classified as having a distinct wet and dry season under Type I of the Philippine Climate Corona classification (DA-Region XI Research Division, 2015).

Experimental Design and Treatments

A 2 x 3 factorial experiment in Complete Randomized Design (CRD) was used in the study. Factor A was the sex of ducks while Factor B was the level of substitutions of Azolla leaf meal in the diet. Six treatment combinations with three replications each were used in the study. A total of apparently healthy, 180 heads of 15-day-old Mallard duck (90 female and 90 male) were used as experimental animals, with a space allocation of 3 ducks/sq.m. There were 10 ducks per replication, or 30 ducks per treatment.

The level of Azolla substitution used was 10% and 20% because a prior study found that a 7.5% level of substitution increased feed intake and body weight gain in broiler chickens (Kumar *et al.* 2018). The author is interested in figuring out what would happen if it were raised to a 10% level. She wanted to assess whether raising it to 20% would have any impact. Additionally, the author was interested in determining whether raising the level of inclusion would be economically feasible.

Analysis and Test of Experimental Treatments

Azolla leaf meal was examined and checked at the Department of Agriculture- Feed Chemical Analysis Laboratory-DA-RFO 3 for proximate analysis.

Table 1

Complete Proximate Analysis of Azolla Leaf Meal

Parameter	Result
% Moisture Content	8.0 ± 0.1
% Crude protein	27.0 ± 0.8
% Ash Content	22.6 ± 3.6
% Crude Fat	3.6 ± 0.6
% Phosphorus	10.5 ± 0.1
Metabolizable Energy	2241.5 kcal/kg

Experimental Ration

Azolla was collected from ponds, washed, drained and dried in sun. The maximum moisture content of the experimental treatment should not exceed 12%. It was ground until it became a leaf

meal. Mixing of the ration was done a day before offering to the Mallard ducks. The replacement of soybean meal with Azolla leaf meal was depended on the percentage amount on the treatment.

Nutrient Requirement of Mallard Duck

Table 2

Composition of experimental ration (mash) and calculated nutrient analysis

Ingredient	B1	B2	B3
Corn, Yellow	58.85	57.15	54.30
Azolla leaf meal	-	3.53	7.06
Soya US	20.00	16.97	12.94
RBD1	5.50	7.00	4.85
FM-Peruvian	6.15	7.50	9.00
Copra Meal	5.35	3.55	5.70
Limestone	1.00	1.00	1.00
Dicalcium phosphate	0.15	0.15	0.15
Molasses	3.00	3.15	5.00
Total	100	100	100
Calculated Analysis			
ME, kcal/kg	2895	2885	2834
C. Protein, %	20.05	20.09	20.09
C. fat, %	4.41	4.57	4.59
C. fiber, %	2.92	3.08	3.33
M+C, %	0.71	0.69	0.66
Lys, %	1.12	1.09	1.03
Ca, %	0.82	0.84	0.87
Threonine, %	0.77	0.74	0.70
Tryptophan, %	0.23	0.21	0.20
P, Av.%	0.34	0.38	0.42

Feed Processing

The manufacture of feeds from available feed ingredients essentially involves a formulation process, acceptance of available feed ingredients, reduction in the size of the raw materials, weighing/proportioning, and mixing of the various ingredients into homogeneous blends (PCAARDDOST, 2015)

Steps in Manual Feed Mixing

1. Feedstuffs were purchased from a dependable source.
2. The raw materials purchased were already ground.
3. Different feed materials were weighed and proportioned of the according to the experimental formulation.

4. Mixed the minor ingredients (lysine, methionine, limestone, salt, premixes) were mixed obtain uniform distribution of the ingredients.
5. The major ingredients (Corn, Soya Us, Azolla leaf meal, RBD1, FM) were mixed using a mixer for five minutes. Minor ingredients were mixed with the major ingredients for another five minutes.
6. The molasses was thoroughly mixed during the process

Management Practices

Housing

The housing used in this study was open-sided for proper ventilation. For the roof, the house was consisted of coconut timber, net, and galvanized iron. The house measured 3x13.5m² and divided into eighteen cages per replication. There were ten ducks per enclosure.

Weighing and Grouping of Birds

The experimental birds' weight was taken and recorded as the initial weight before the study began, and distributed to their respective pens. Random picking was carried out by grouping the birds to their respective treatment. The birds' final weight was taken and recorded at the end of the study.

Feeds and Feeding

During the course of the analysis, mash form of feed was fed to the ducklings. Formulated starter feeds (corn +soybean meal, 10% azolla inclusion, and 20 % azolla inclusion) were given three times a day to the ducklings from the beginning until the end of the study and were given from age 22 to 82.

Provision of Drinking Water

Throughout the study sufficient water were given at all times. This allowed the ducks to get deep, allowing their heads to immerse and not themselves to prevent the scaly and rusty eyes that may cause blindness.

Sanitation Practices

During the experiment, the elimination of manure was performed to avoid foul odors and to prevent disease-causing diseases. Thorough cleaning of feeders and waterers was done on a daily basis.

Statistical Analysis of Data

The data obtained were evaluated following the Analysis of Variance (ANOVA), and treatment differences were compared by applying the Least Significant Difference (LSD) test.

Results and Discussions

Mean Gain in Weight

In this study, individual effects on gain in weight values of ducks raised fed with formulated diet with corn and soybean meal were not significantly different to 10% level of azolla substitution but were significantly higher at 5% level of significance than the ducks raised fed with 20% level of Azolla substitution. This difference could be related to the fact that Azolla leaf meal had a high fiber content and ducks were less capable of digesting cellulosic materials.

Poorer weight gain of ducks (male and female) fed a diet containing 20% of azolla leaf meal could be attributed to the lower feed intake and therefore a reduced metabolizable energy intake. This observation was noted especially during the first two weeks of feeding when most of the ingredients left in the feeding troughs were basically azolla meal. This means that ducks refused to consume higher inclusion rates of azolla meal in the diet possibly due to its higher fiber content.

Previous reports made by Basak et al. (2002) and Beckangham et al. (1978) have implicated high levels of ADF (30.08) and lignin (28.42) as the main factor limiting the efficient utilization of azolla meal by monogastric animals. Further analysis of the interaction between the combined sex of ducks and the level of substitution showed that there was no significant difference in weight gain. As a result, azolla meal can be used as a substitute since control treatment was already a standard diet.

Table 3

Mean gain in weight (kg) of the mallard ducks as affected by varying levels of azolla substitution.

Level of Substitution	Sex of Ducks	
	A1 Male	A2 Female
B1-formulated mash ration (soybean + corn)	0.71a	0.78a
B2-formulated mash ration with 10% Azolla substitution	0.75a	0.74a
B3- formulated mash ration with 20% Azolla substitution	0.65b	0.60b

Note: *Different letters (x-y) following the means between rows (sex of ducks) are significant at 5% (LSD) level. Different letters (a-c) following means between columns (level of substitution of Azolla) are significant at 5% (LSD) level.

*Means of the same letter are not significantly different.

Mean Feed Consumption

Table 4 below shows that the sex of ducks has significant effect on the feed consumption at 5% level of significance with F=7.05 as the female consumed more feeds (control and 10% azolla inclusion) than the male ducks. Steczny K. *et al*. (2017) stated that compared with females, males

consumed less feed to 21 days old. However, they showed a poorer feed conversion ratio (FCR) per kg of the weight gain over that period.

Further review disclosed that there was noteworthy effect on the level of substitutions as to the feed consumption at 5% level of significance with F= 4.38. The result shows that experimental ducks fed with the control diet consumed more feeds than with the higher level of inclusion (20%); however, it must be noted that feeding with 10% inclusion was comparable and exhibited good results. The lower feed consumption of ducks fed azolla meal at 20% indicated that palatability may have been adversely affected by its inclusion. This observation is justified by the relatively high amount of azolla meal observed in the leftovers of the experimental birds.

This is consistent with the study conducted by Bestat and Morenton (1985) and cited by Basak (2002) that azolla affected the palatability of the feed resulting in reduced feed consumption. Moreover, the analysis on the relationship between the sex of ducks and the level of substitution indicated that there was no indicative effect on feed consumption.

Table 4

Mean feed consumption (kg) of the mallard ducks as affected by varying levels of azolla substitution.

Level of Substitution	Sex of Ducks		
	A1 Male	A2 Female	A1 Male
B1-formulated mash ration (soybean + corn)	4.73	4.89	4.81a
B2-formulated mash ration with 10% Azolla substitution	4.53	4.80	4.67ab
B3- formulated mash ration with 20% Azolla substitution	4.09	4.65	4.37b
Mean	4.45y	4.78x	

Note: *Different letters (x-y) following the means between rows (sex of ducks) are significant at 5% (LSD) level. Different letters (a-c) following means between columns (level of substitution of Azolla) are significant at 5% (LSD) level.

*Means of the same letter are not significantly different.

Mean Feed Conversion Ratio

The table 5 revealed that the experimental male ducks fed with 20% level of substitutions has a notably effect on the feed conversion ratio at 5% level of significance at F=4.09. The least feed conversion ratio was attained by experimental ducks fed with 10% level of substitution. Further study revealed that amongst the different treatment combinations, ducks from A2B3 (Female Mallard ducks fed with 20% Azolla substitution) showed the highest feed conversion ratio at 7.75, while the ducks that had the lowest feed conversion ratio were the ducks from A1B2 at 6.05. This means that it takes 7.75kg

and 6.05kg of feeds to increase the weight of mallard ducks by 1 kilogram for both treatments, respectively. Increase feed intake or decrease gain in weight contributed to the FCR.

For the interactions of the combined effects of the sex of ducks and the Azolla substitution, it was found out that there was a significant effect at 5% level of significance with F = 5.71 on 20% substitution level. This finding explains that the ability of ducks to convert feed into meat depends on the composition and structure of the feeds. This is consistent with the idea put forward by Bukingham *et al*. (1978) that the growth rate is attributed to the high level of ADF (acid detergent fiber) and lignin content of azolla meal, which is a factor limiting the efficient use of azolla in monogastric animals.

This also confirmed the findings of Castillo *et al.* (1981) that monogastric animals such as broilers are inefficient in digesting cellulosic materials such as high fiber content found in azolla meal. While Basak *et al.* opined that higher levels of fiber in aquatic plants could be the reason for decreased use of nutrients and ultimately reduced FCR.

Based on the results of the study, it was evident that the inclusion of a 10% substitution level can be used as a substitute since it obtains the least FCR in comparison to the control diet, which means that mallard ducks can convert meat with a lower feed intake efficiently.

Table 5

Mean feed conversion ratio of the mallard ducks as affected by varying levels of azolla substitution.

Level of Substitution	Sex of Ducks		Mean
	A1 Male	A2 Female	
B1-formulated mash ration (soybean + corn)	6.68	6.26b	6.47
B2-formulated mash ration with 10% Azolla substitution	6.04	6.45b	6.24
B3- formulated mash ration with 20% Azolla substitution	6.29	7.75a	7.02*

Note: Different letters (x-y) following the means between rows (sex of ducks) are significant at 5% (LSD) level. Different letters (a-c) following means between columns (level of substitution of Azolla) are significant at 5% (LSD) level.

(*) Following the means between rows (combinations) are significantly different

Mean Dressing Percentage of Male and Female Mallard Duck Given Mash Feeds with Azolla Leaf Meal Inclusion

Dressing percentage was one of the most important parameters for the determination of the marketable portion of poultry. The higher the dressing percentage, the higher the profit. A further test was carried out and stated that there was no compelling effect on the dressing percentage with respect to the sex of ducks, the level of substitution and interaction on the combined effects of Azolla. It was

noted that the 10% inclusion of azolla meal in the diet had a promising outcome and was consistent with control.

This is consistent with the Basak *et al.* (2002) investigation into the use of Azolla pinnata meal as an additional 5 per cent feed for commercial broiler chicks in Bangladesh, which found that dressing and giblet percentages increased significantly with 5 per cent azolla meal. The dressing percentage ranged numerically between the different groups and the higher dressing percentage was recorded in T3 followed by T2, T4 and the lowest in T1. p. Basak *et al.* (2002) reported similar findings that the use of Azolla meal in the broiler ration improved performance and was used as a safe diet. However, variation in observation may be due to differences in bird species, levels of Azolla powder inclusion, agro-climatic conditions, and other factors. Higher dressing percentage in T3 and carcass yield in T4 may be due to the positive influence of Azolla powder, which has increased the body weight of the broilers. Similar findings were also reported by Basak *et al.* (2002); Naghshi *et al.* (2014) who also reported higher dressing and carcass yields when Azolla was added to the broiler diet.

Table 6

Dressing percentage of the mallard ducks as affected by varying levels of azolla substitution.

Level of Substitution	Sex of Ducks	
	A1 Male	A2 Female
B1-formulated mash ration (soybean + corn)	80.87	73.34
B2-formulated mash ration with 10% Azolla substitution	74.70	76.36
B3- formulated mash ration with 20% Azolla substitution	79.14	71.26

Note: *Different letters (x-y) following the means between rows (sex of ducks) are significant at 5% (LSD) level. Different letters (a-c) following means between columns (level of substitution of Azolla) are significant at 5% (LSD) level.

*Means of the same letter are not significantly different.

Optimum Level of Azolla Leaf Meal as a Protein Substitute

With regard to the optimum level of substitution of Azolla, it was observed in the Table3, mean gain in weight (kg) of the mallard ducks as affected by different treatments that there was a decrease in the mean weight gain of mallard ducks, as the substitution of Azolla increased by 20% compared to 10% for both male and female ducks. Similarly, when it comes to feed consumption, it was noted that 10% substitution consumed more feed than any other diet, although it was almost on the control diet.

In addition, it was noted in the experiment that the minimum amount of feed required to produce one kilo of meat was shown to be the lowest value of the average FCR of 6.05. This means that ducks on a 10% substitution diet have converted feeds into weight gain more efficiently compared to ducks on a 20% substitution basis. In addition, male and female mallard ducks with 10% substitution performed

well on their dressing percentage. In the end, based on the results of the study, the most optimal substitution of Azolla was 10%, and the application and decision will depend on which factor the farmer wanted to consider.

Cost and Return Analysis

As shown in Table 7, the cost and return analysis of mallard ducks fed with different treatments showed that 10% of azolla meal in male and female mallard ducks was ranked second highest in terms of net income at 810.59 and 1.133.23; ROI at 25.73 and 29.69; and total live weight at 33.00 kg which have a positive effect on earning more profits. Azolla meal with 10% inclusion may be used as a replacement for soybean meal although the highest net income and return on investment was achieved by female ducks in the control treatment and this was attributed to the fact that the formulated starter with corn and soybean meal was already the standard feed given to the ducks and sold the produced liveweight at a high price.

In addition, the highest ROI and net income of female mallard duck subject to 10% inclusion was achieved due to the fact that it was sold at a higher price, which is why it can compensate for the high cost per unit. Female and male mallard ducks earned 33.00 kg of break points, which means that a farmer needs to produce a higher live weight than that to make better income. Moreover, male mallard duck that was subjected also to 10% inclusion exhibited lowest cost per unit that is why it obtained better profits.

Table 7

Cost and return analysis of mallard ducks as affected by varying levels of azolla substitution.

	B1-Corn + Soybean meal		**B2-10% Azolla Inclusion**		**B2-10% Azolla Inclusion**	
	A1-Male	**A2-Female**	**A1-Male**	**A2-Female**	**A1-Male**	**A2-Female**
SALES						
Total weight produced (kg)	32.10	34.50	33.00	33.00	31.10	30.00
Sales of Mallard duck (PHP120/kg-male; PHP150/kg-female	3,852.00	5,175.00	3,960.00	4,950.00	3,372.00	4,500.00
GROSS SALES (PHP)	**P3,852.00**	**P5,175.00**	**3,960.00**	**4,950.00**	**3,372.00**	**4,500.00**
EXPENSES						
Stocks (PHP)	600.00	1,050.00	600.00	1,050.00	600.00	1,050.00
180 heads of mallard duck at PHP20 (male) and PHP35 (female)						
Feeds						
Starter feeds (PHP)	2,611.15	2,700.79	2,386.35	2,603.71	2,238.70	2,539.80
Labor cost at P0.04/hd/day x 60days (PHP)	72.00	72.00	72.00	72.00	72.00	72.00
Housing (depreciation cost-PHP)	P91.06	P91.06	91.06	91.06	91.06	91.06

TOTAL EXPENSES (PHP)	**3,374.21**	**3,913.06**	**3,149.41**	**3,816.77**	**3,001.76**	**3,752.86**
NET INCOME (PHP)	**477.79**	**1,261.94**	**810.59**	**1,133.23**	**730.24**	**747.14**
ROI (%)	**14.16**	**32.24**	**25.73**	**29.69**	**13.99**	**19.90**
BREAK EVEN POINT	**32.10**	**34.50**	**33.00**	**33.00**	**31.10**	**30.00**
COST PER UNIT	**105.11**	**113.42**	**95.43**	**150.00**	**96.51**	**150.00**

Conclusion

1. The results of the study revealed that the azolla meal diets have nutritive and feeding values based on the proximate analysis conducted. Azolla at 10% level in the diet improved gain in body weight, feed consumption and FCR for both sexes of ducks.
2. On the other hand, the most optimal substitution of Azolla was 10%, as there were no significance differences among the different treatment combinations particularly the control treatment.
3. Based on the outcome of the study, it was stated that there was no compelling effect on the dressing percentage with respect to the sex of ducks, the level of substitution and interaction on the combined effects of azolla. It was noted that the 10% inclusion of azolla meal in the diet had a promising result and was consistent with control.
4. On the cost and return analysis, inclusion of 10 % azolla meal on the diet of male mallard ducks ranked the first in ROI and total liveweight produced that have a positive impact to gain a higher ROI and net income. Generally, it may be further concluded that Azolla is a good source of protein and may be used up to 10% level in ducks' diet for better performance.

Recommendations

Based on the results obtained, the following are recommended.

1. Further study on other level of replacement of azolla to soybean meal are encouraged to gain additional knowledge about its effects on the growth performance of mallard ducks focusing on only one sex and other animals such as swine and ruminants, as an alternative source of protein.

2. Additional study on feeding fresh azolla for mallard ducks as substitute for soybean meal may also be tried to discover the optimum level of replacement.

3. Further study on lowering the inclusion of azolla leaf meal to determine the effects on dressing and carcass yield percentage with respect to the sex of ducks.

4. Based on the result of the study, azolla may be advised to use as an alternative feed substitute to reduce the cost of producing ducks and other farm animals. It is an unconventional feed ingredient at low price and may be used as a poultry feed to reduce the cost of production and could be a sustainable replacement option to save the cost of feeds in particular.

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“Trust in the LORD with all your heart; and lean not to your own understanding. In all your ways acknowledge him, and he shall direct your paths”. Proverbs 3:5

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