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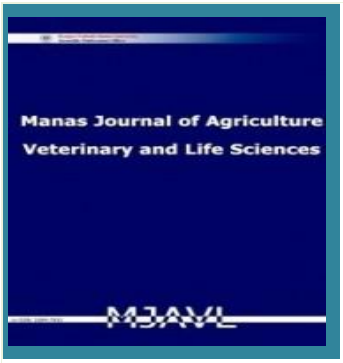

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Research Article

Socio-Economic Structure, Production Practices, Observations and Suggestions in Nomadic Sheep Production in Ordu province located in Black-Sea Region of Türkiye

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ABSTRACT

Products obtained from farm animals meet the need for animal protein, which has an important place in human nutrition. In recent years, the demand for the products of small ruminants has been increasing. Products obtained from small ruminants are important in meeting the nutritional needs of the world population. Especially in light of the effect of global warming, small ruminants production has become even more important. Especially considering the production conditions of small ruminants, the nutritional needs of animals are met by grazing in the existing highlands. This study was conducted in Ordu province, located in the Black Sea Region of Türkiye. The Black Sea region, with its coasts and springs, is a region where breeders engage in nomadic animal husbandry. In the study, it was determined that 86.6% of the nomadic sheep breeders are producing Karayaka breed sheep while 13.4% are breeding Karayaka crossbreds. In the study, 47.9% of the breeders who participated in the survey live in the village and 45.1% live in the district. Percent 94.4 of the breeders were male and 5.6% were female. It was determined that 32.4% of the breeders were between the ages of 41-50 and 40.8% were primary school graduates. The rate of those who contribute to their livelihood through husbandry is 57.2%. The rate of those who want to continue small ruminant farming in the future is 82.9%. Additionally, it was determined that the majority of breeders attach importance to record keeping and animal health protection practices. In the enterprises where the study was conducted, difficulties were encountered in supplying feed and finding shepherds, and high feed prices and labor costs were stated as the most common problems. In nomadic sheep breeding, grazing and climate parameters in pastures and plateaus have a significant impact on the nutrition of the animals. Therefore, facilitating the transportation of sheep to pastures and plateaus and the sustainability of these areas will positively affect nomadic sheep breeding.

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INTRODUCTION

Small ruminant production is an economically important value in our country and in the world, and its place in human nutrition is quite high in terms of the yields obtained. Small ruminants, which can adapt to different environmental conditions, can travel for a long time in the pasture, make good use of inefficient areas that cannot be used for crop production and unused agricultural lands despite adverse climatic conditions, and can also provide many animal products. Due to these advantages, small ruminant production is widely practiced all over the world. There are 2,396,134,564 heads of small ruminants in the world. In Türkiye, the total number of small ruminants is 57,519,204 heads, and 45,177,690 heads of this number are sheep (FAO, 2023). Sheep production is importance in Ordu province located in the Black Sea Region. Due to its mountainous, rugged terrain, climate and socio-economic structure, the Black Sea region has a suitable structure for small ruminant production in animal husbandry activities, as well as an important source of income for the people of the region (Tozlu Çelik, 2016). The topographic structure and climatic conditions of our country are very favorable for various animal husbandry activities. In addition, features such as high mountainous areas, changes in elevation in a short distance, and different climatic values create two different grazing areas as winter pasture and spring pasture throughout the year (Hadimli et al., 2010; Alkan, 2020).

Nomadic small ruminant husbandry is an animal production activity that takes place in places with rich plant diversity in areas that are not suitable for crop production, especially in high, mountainous areas (Kutlu, 1987). Nomadic animal husbandry is an activity that is shaped and changed according to the climatic conditions, geographical potential and social conditions (Leach, 2001; Yılmaz et al., 2014; Yazıcı, 2016a; Yazıcı, 2016b), and displacement in nomadic animal husbandry depending on the climate is also compatible with the natural life of the animal (Sayılır, 2012). Nomadic animal husbandry can be practiced in every region of Türkiye. This situation reflects the richness of nomadic ovine husbandry activity in our country (Kutlu, 1987). The main purpose of nomadic animal husbandry, which is frequently seen in the world, is to provide optimum environmental conditions for animals by taking animals to high altitude springs and pastures, especially in hot summer months, to reduce the effect of heat stress, as well as to ensure profitability by providing cheap and high quality roughage for feeding animals (Daşcı and Çomaklı, 2006; Herzog and Seidl, 2018; Yazıcı, 2016a; Savaş et al., 2019a).

In addition to supporting families engaged in nomadic animal husbandry, which is a traditional lifestyle and a culture that needs to be preserved within animal husbandry activities, it is necessary to improve their current conditions and to propose solutions to their problems (Uzun and Köse, 2012; Aygün and Sezgin, 2009). In addition to being a source of livelihood, nomadic sheep production has a great role in contributing to the national economy and in the sustainability of small ruminant husbandry (Yılmaz et al., 2020). In Türkiye, in sheep farming activity, which has a very important position, the sustainability of sheep farming activity is of importance in economic, social and environmental dimensions (Yücel, 2022). Although sheep have many productivity aspects, the region where they will be bred along with the yield aspect, environmental conditions, market opportunities and grower conditions are also issues that should be taken into consideration. (Selvi, 2021). Although production practices vary regionally in our country, nomadic animal husbandry is widely seen in small ruminant production. However, in addition to the decrease in pastures in our country, summer pastures, migration routes, winter pasture supply, transportation problems, and problems encountered in the evaluation of the products obtained, some problems arise not only for the people who make a living with nomadic sheep farming, but also for family members (Yılmaz et al., 2014; Yılmaz et al., 2020; Yılmaz and Coşgun, 2017; Savaş et al., 2019a). To ensure the sustainability of pastures and plateaus for nomadic livestock production and to make good use of them, special attention should be paid to the grazing pattern and grazing period in these areas. Although the time of ascent and descent to the plateaus varies for each settlement in Türkiye, the elevation of the plateau and the climatic characteristics of that year are also among the determining factors (Özalp and Sütlü, 2011; Palta and Genç Lermi, 2018). All these developments make nomadic animal husbandry difficult and make it a less preferred animal husbandry practice. In addition to hazelnut production as an agricultural activity in Ordu province, sheep production is also widely practiced. In certain periods of the year, the sheep are raised in the pens on the coast and taken to the highlands with the warming of the weather. The

aim of this study is to determine the socio-economic structure, production practices and problems encountered by the breeders in nomadic sheep farming enterprises and to offer suggestions to address these problems.

MATERIAL AND METHOD

The material of the study consisted of survey data obtained from 71 enterprises engaged in nomadic sheep production in Ordu province. In this study, data were collected from sheep breeders by face-to-face survey study survey using simple random sampling method. The evaluation of the obtained data was analyzed with the SPSS (26.0 Version) statistical program Analyze, Descriptive Statistics, and Frequencies. The results obtained from the data obtained within the scope of the research are presented through percentage and frequency values.

In similar survey studies, it was reported that at least 3% (Yamane, 2010) or 10% (Sümbüloğlu and Sümbüloğlu, 2000) of the population would be sufficient to determine the sample size. In this study, the number of sample enterprises to be surveyed was calculated using the following formula within 10% sampling error and 95% reliability limits (Alkan and Türkmen, 2020; Alkan and Türkmen, 2021; Çiçek and Erkan, 1996; Satar et al., 2022).

$n= N.t^2 .p.q / d^2 . (N-1)+t^2 .p.q$

n: sample size
N: Population size (1000)
t: t ruler value at 95% confidence interval (1.96)
p: 0.5 (50% incidence)
q: 0.5 (50% incidence)
d: Sampling error (0.10)

RESULTS AND DISCUSSION

General Characteristics of Enterprises and Herd Management

In the study, 47.9% of the breeders who participated in the survey live in the village, 45.1% in the town and 7% in the city center. It was determined that 86.6% of the nomadic sheep breeders are producing Karayaka breed sheep while 13.4% are breeding Karayaka crossbreds. Percent 94.4 of the breeders were male and 5.6% were female. When evaluated according to age ranges, 32.4% of the breeders are 41-50 years old and this age group constitutes the majority (Table 1). Percent 87.3 of the breeders were married and 39.5% were high school-university graduates, 40.8% were primary school graduates and 19.7% were secondary school graduates. The number of families with 3-7 or more households constitutes the majority (93%). The proportion of single farmers is 70.4%. Percent 90.2 of the breeders reported that the ownership of their enterprises belonged to them. In terms of the possibility of establishing livestock enterprises, it was determined that 85.9% of the breeders established their enterprises with their own means. It was observed that those who used their own means and loans for financing needs were few (Table 1). In the study conducted by Satar et al. (2022), the rate of credit utilization (24.0%) is higher than this study. Hazelnut production is widespread in the location where this study was conducted. Economic income is provided from both crop and sheep production.

In the study, it was determined that the majority of the breeders were between 41-50 years old. This finding is similar to the average age of the breeders (49 years old) reported by Karadaş (2018) and (48.2 years old) reported by Özsayın and Everest (2019). These studies show that people engaged in sheep production are mostly over 40 years old. Sheep farming, as a business line, should be considered within the scope of health insurance. In this way, young people can be directed to animal husbandry. Directing young people towards small ruminant production is very important for the continuity of animal husbandry activity. Under the effects of global

warming, food resources have become an important issue that needs to be emphasized more and more. In the study, the number of primary school graduates (40.8%) is lower than that reported by Karadaş (2018) (64.7%). In recent years, the tendency of high school and university graduates towards sheep production is important for the sustainability of small ruminant breeders. The value found for the household (3-7 or more people) in the study is similar to that reported by Özsayın and Everest (2019) (4.2).

Table 1. *Socio-economic status of nomadic sheep breeders*

Residence	**n**	**%**	**Number of households**	**n**	**%**
Province centre	5	7.0	1-2	5	7.0
Town	32	45.1	3-7 and above	66	93.0
Village	34	47.9	**Education status**		
Age			Primary school graduate	29	40.8
19-30	9	12.7	Secondary school graduate	14	19.7
31-40	16	22.5	High school-University graduate	28	39.5
41-50	23	32.4	**Ownership status**		
51-60	14	19.7	Individual	64	90.2
61 and above	9	12.7	Tenant-partner	7	9.8
Gender			**Establishment of a business**		
Woman	4	5.6	Own means	61	85.9
Male	67	94.4	Own means-use of credit	10	14.1
Profession			**Marital status**		
Farmer	50	70.4	Single	9	12.7
Farmer - Other occupations	21	29.6	Married	62	87.3

When the reason why breeders engage in animal husbandry is examined, 51.4% contribute to their livelihood. It was determined that 15.7% of them do not have any income and earn their living only by husbandry. In all of the farms where the study was carried out, husbandry is carried out as winter and spring pasture. In this respect, in Ordu province, grazing is carried out under hazelnuts in winter and production is carried out by migrating to pastures and highlands in summer. The availability of grazing areas for small ruminant animals affects sustainability. Temperature and humidity can cause stress in sheep. In this respect, nomadic production has made it compulsory to migrate from coastal areas where heat and humidity are felt intensely to the highlands.

The rate of those who have been engaged in sheep production for 11-30 years was 49.2%. This rate is higher than those who have been doing sheep farming for 0-10 years (25.4%) and 30-40 years and above (25.4%) (Table 2). Those who gave the answer of additional income as the reason for sheep production were 57.2% and their own needs were found to be 27.1%. It was determined that most of the sheep breeders were engaged in sheep production for additional income.

The rate of those who answered yes to the desire to do animal husbandry in the future was 82.9% (Table 2). This finding is consistent with the finding reported by Satar et al. (2022) (61.1%). In this respect, it is seen that the willingness to continue animal husbandry in the following years is high. The rate of record-keeping on sheep farms is 82.6%. This finding is similar to that reported by Özsayın and Everest (2019). High record-keeping is very important in terms of production studies in sheep production and the sustainability of enterprises. It is seen that 94.2% of the information on animal husbandry was obtained from the internet, TV and district agriculture and forestry directorates. Those who are engaged in other animal husbandry activities other than sheep production are 32.3%. The rate of those who are only engaged in sheep production and animal husbandry activities is 67.7%.

Enterprises with a herd size of 100-200 heads constitute the majority with 54.3%. Among the enterprises, 12.8% of the enterprises with 200-500 head and more sheep were found. The rate of those who reported an increase in the number of sheep in recent years is 71.4%. 65.7% of the breeders use shepherds and the rate of those who use permanent shepherds is 50.8%. The rate of those who are members of livestock producer organizations is 77.5%. The fact that this rate is high shows that breeders attach importance to benefiting from livestock support. In our study, it was determined that the number of members of agricultural producer organizations was high.

This finding is similar to the finding of Özsayın and Everest (2019) and Yılmaz et al. (2020) that breeders are members of different cooperatives and producer organizations. It is possible for sheep breeders to benefit from agricultural supports by being aware of agricultural supports through their membership in breeders' associations.

On the farms where the study was conducted, the experience of the breeders in this business is mostly between 11-30 years. This finding is similar to the 27 years of sheep production experience reported by Karadaş (2018) and the average of 24 years reported by Özsayın and Everest (2019). According to the findings obtained in the study, it shows that in addition to the intensive hazelnut cultivation in Ordu province, sheep production is also important. In addition to hazelnut production, sheep production plays an important role in the livelihood of the breeders.

Table 2. *General characteristics of nomadic sheep enterprises*

Reason for keeping livestock	**n**	**%**	**Purpose of production**	**n**	**%**
Contribution to livelihood	36	51.4	Own need	19	27.1
No other income	11	15.7	Butchery-victim	4	5.7
Habit	23	32.9	Breeding	7	10.0
Professional experience (year)			Additional income	40	57.2
0-10	18	25.4	**Future livestock production status**		
11-30	35	49.2	Yes	58	82.9
30-40 and above	18	25.4	No	12	17.1
Other animal husbandry activity			**Record keeping**		
Yes	21	32.3	Yes	57	82.6
No	44	67.7	No	12	17.4
The way of obtaining information on animal husbandry			**Herd size**		
Self-family	4	5.8	0-100 head	23	32.9
Internet- TV-district directorates	65	94.2	100-200 heads	38	54.3
Membership to producer organisation			200-500 heads and above	9	12.8
Member	55	77.5	**Shepherd situation**		
No membership	16	22.5	Yes	46	65.7
Increase in the number of sheep in recent years			No	24	34.3
Yes	50	71.4	**Shepherd usage time**		
No	20	28.6	Seasonal	18	28.6
			Permanent	32	50.8
			Family and seasonal	13	20.6

Percent 62.4% of the enterprises supply breeding males from their own flocks (Table 3). Breeding females were supplied by 81.2% of the breeders from their own flock. In the enterprises, the ratio of those who prefer 15 months of age for breeding females was determined as 67.2%, and the ratio of those who prefer 15 months of age for breeding males was determined as 57.4%. The findings obtained in this study are similar to those reported by Yılmaz et al. (2020).

In the study, it was determined that mating was intensive in July (46.9%) and August (21.9%). Mating was 17.1% in May-June, 12.5% in September-October and 1.6% throughout the year. The rate of those who answered that mating lasted 60 days was 56.5%, the rate of those who continued mating throughout the year was 31.9% and the rate of those who continued mating for 30-45 days was 11.6%. It was determined that lambs were mostly born in November-December-January (49.2%) and January-February-March (47.5%). The proportion of breeders who reported that lambing continued throughout the year was 3.3%. Lambs are born in the first months of the year, which enables them to grow until they leave for the plateau. Lambs are sold after they come from the plateau. Lamb sales are an important source of income.

It was determined that lamb births lasted two months (33.3%) and three months (31.7%). While the rate of those who did not separate the lambs from the mother as weaning period was 36.2%, lambs were weaned in two months (15.9%), three months (17.4%) and 6 months (30.5%). Butchering sales are realized as lambs (55.1%). Table 3 shows that the most important income of sheep breeders in the enterprises where the study was

conducted was obtained from lamb + breeding and sacrificial sales with a rate of 78.3%. The breeding periods of females are mostly 5 years (47.1%) and 6 years (35.3%). The breeding periods of rams were mostly 2-3 years (57.4%) and 4 years (27.9%). The rate of pasture utilization was 85.3% and the pasture composition was mostly (68.1%) good. The grazing status of different species in the pasture was 84.1%. It was observed that sheep, goats and cattle (75.4%) used the same pasture.

Table 3. *Herd management practices*

Breeding (male)	**n**	**%**	**Lamb weaning (month)**	**n**	**%**
Own flock	43	62.4	2	11	15.9
Animal market-neighbouring businesses	26	37.6	3	12	17.4
Breeding (female)			6	21	30.5
Own flock	56	81.2	Doesn't discriminate	25	36.2
Animal market-neighbouring businesses	4	5.8	**Butchery sale**		
All of them	9	13.0	Lamb	38	55.1
Breeding age female (months)			1-2 years and over	31	44.9
12	6	9.4	**Most important income**		
15	43	67.2	Breeding sale	8	11.6
18	6	9.4	Lamb-breeding and sacrifice	54	78.3
24	9	14.0	Sacrifice	7	10.1
Breeding age male (months)			**Breeding use period female (years)**		
12	16	26.3	5	32	47.1
15	35	57.4	6	24	35.3
18 and over	10	15.3	7	12	17.6
Pasture water source			**Duration of use in breeding male (years)**		
Mains water	6	8.7	2-3	39	57.4
Spring water	63	91.3	4	19	27.9
Pasture composition			Over 5	12	14.7
Good	47	68.1	**Different types of grazing in the pasture**		
Bad	4	5.8	Yes	58	84.1
Medium	18	26.1	No	11	15.9
Pasture utilisation status			**Grazing species on pasture**		
Yes	58	85.3	Sheep-goat-cattle	49	75.4
No	10	14.7	Sheep-goat	16	24.6

Feeding and Feed Supply Status of Enterprises

As seen in Table 4, it was determined that the maximum pasture grazing time of animals was 4 months (39.0%), the minimum was 1-2 months (43.6%) and the maximum stay time in the barn was 6 months (38.9%). During the stay in the barn, winter grazing is carried out in hazelnut gardens at sea level. In this respect, grasses under hazelnut are utilized as a feed source in winter. The rate of those who gave hay as roughage was 91.4% and the rate of those who gave vetch as roughage was 82.9%. Percent 98.6 of the breeders do not produce concentrate feed. Breeders who provide supplementary feeding are 69.6%. The proportion of those who make supplementary feeding in both periods, including the birth period and mating period (50.7%) is high. It is seen that the majority of sheep farms (82.4%) use lick stones for their animals.

In Table 4, the rate of those who declared that there is a pasture in the village was 73.9%, the rate of those who go to the pasture was 97.1% and the rate of those who reported that they have been going to the pasture for many years was 98.6%. The time for going out to pasture is intensively in April (53.2%), going out to pasture in May (80.8%), transitioning from plateau to pasture in October (50.9%), and transitioning from pasture to hazelnut gardens in December (61.1%). Savas et al. (2019b) found that in the study conducted in Iğdır province, the number of people going to pasture in April was higher (86.8%). In our study, it was found that more people went to pasture in April (53.2%). With this finding, Savaş et al. (2019b) are similar to what was reported. The maximum duration of stay in pasture and plateau was 6 months (59.7%) and the maximum duration of stay in

settlement was 6 months (60.3%). It was found that the mode of travel to the plateau was preferred on foot (44.8%). The rate of those who apply both vehicles and walking is 40.3%.

Table 4. *Practices for feeding and feed supply*

Feeding place upland duration (month)	**n**	**%**	**Feeding place pasture duration (month)**	**n**	**%**
2-3	7	11.9	1-2	28	45.2
4	23	39.0	3-5	9	14.5
5	17	28.8	6	14	22.6
6-7	12	20.3	7-8	11	17.7
Feeding place barn (month)			**Time to go out to pasture**		
2-3	10	18.6	March	9	14.5
4	6	11.1	April	33	53.2
5	11	20.3	May	20	32.3
6	21	38.9	**Time to go to the plateau**		
7	6	11.1	May	42	80.8
Does the village have a plateau			June	7	13.5
Yes	51	73.9	July	3	5.7
No	18	26.1	**Transition month from plateau to pasture**		
The way to the plateau			September	8	14.0
Vehicle	10	14.9	October	29	50.9
Walking	30	44.8	November	20	35.1
Vehicle-walk	27	40.3	**Transition month from pasture to garden**		
Duration of stay in pasture (month)			November	7	13.0
2-4	2	3.0	December	33	61.1
5	19	28.3	January	14	25.9
6	40	59.7	**Additional feeding**		
7-10	6	9.0	Yes	48	69.6
Duration of stay in the settlement (months)			No	21	30.4
2-4	5	7.4	**Additional feeding status**		
5	3	4.4	Mating	13	18.8
6	41	60.3	Birth period	7	10.2
7-8	19	27.9	Both periods	35	50.7
Use of hay for roughage			Not doing	14	20.3
Yes	64	91.4	**Use of a lick stone**		
No	6	8.6	Yes	56	82.4
Use of vetch for forage			No	12	17.6
Yes	58	82.9			
No	12	17.1			

Health Protection Practices of Enterprises

In the study, it was determined that 93.6% of the breeders did not milk the sheep. Breeders attach importance to the feeding of lambs. Therefore, sheep are not milked. The milk yield of Karayaka sheep is 30-45 kg, and the lactation period is 100–140 days (Akçapınar, 2000). In Turkey, most sheep herds are kept in small flocks, and milk is generally obtained from sheep by the manual milking method (Ünal et al., 2008). In the nomadic sheep farms where the study was carried out, milk evaluation was not carried out due to the lack of a sufficient labor force and the marketing of the products obtained. by the manual milking method (Ünal et al., 2008). In the nomadic sheep farms where the study was carried out, milk evaluation was not carried out due to the lack of a sufficient labor force and the marketing of the products obtained. On all the sheep farms, it was reported that health checks were carried out by the veterinarian. When there is a problem in the flock, the veterinarian called (69.1%). Early intervention is important to prevent the spread of diseases on livestock farms. It is seen that breeders are sensitive about health practices. It is seen that 86.8% of the breeders comply with the vaccination calendar and prefer to have the vaccine done by veterinarians (34.3%). In addition, the rate of those who make their own vaccines is 29.9%. 96.6% of the breeders reported that sheep were vaccinated in accordance with the vaccination calendar. The findings obtained as a result of the study in terms of vaccination practices are similar to the finding of Savaş et al. (2019a) that attention is paid to vaccination practices in nomadic livestock farms in

Igdir province. The most common period of animal losses is spring (49.3%). It can be said that calf losses are high in this period. Especially the continuation of diarrhoea in the calf increases the calf losses. It is recommended to vaccinate against feeding-induced diarrhoea and jaundice, especially during the transition period from pen to pasture grazing (Savaş et al. 2019a).

As seen in Table 5, the rate of those who reported that there was no disease in their flocks in the sheep farms where the study was conducted is 78.3%. All of the breeders carry out parasite control. It is seen that parasite control is mostly done in the spring-autumn months (91.4%). Breeders reported that they prefer drug-injection application (56.5%) in parasite control. The rate of those who apply disinfection to sheep farms is 97.1%. It was reported that disinfection applications were performed every month during the year (89.7%). On sheep farms, 39.1% of the breeders stated that they performed manure cleaning twice a year.

Table 5. *Health protection* practices *in the herd*

Disease status	**n**	**%**	**The person to be called for health problems in the herd**	**n**	**%**
Insidence	15	21.7	Veterinarian	52	76.4
Absence	54	78.3	Provincial directorates-breeder associations-veterinarians	16	23.6
Parasite control method			**Compliance with the vaccination schedule**		
Medicine	22	31.9	Yes	59	86.8
Injection Moulding	8	11.6	No	9	13.2
Medicine-injections	39	56.5	**Vaccination person**		
Fertiliser cleaning			Veterinarian	23	34.3
1	23	33.4	Our own	20	29.9
2	27	39.1	Provincial-district directorates	9	13.4
3	15	21.7	All of them	15	22.4
4	4	5.8	**Time of animal losses**		
Disinfection			Spring	34	49.3
Yes, once a year	7	10.3	Winter	15	21.7
Yes, every month	61	89.7	In both periods	20	29.0
Agricultural supports utilised			**Month of parasite control**		
Government subsidies	10	18.1	Four seasons	6	8.6
Bank loan support	6	11.0	Spring-Autumn	63	91.4
State and bank loan support	39	70.9			

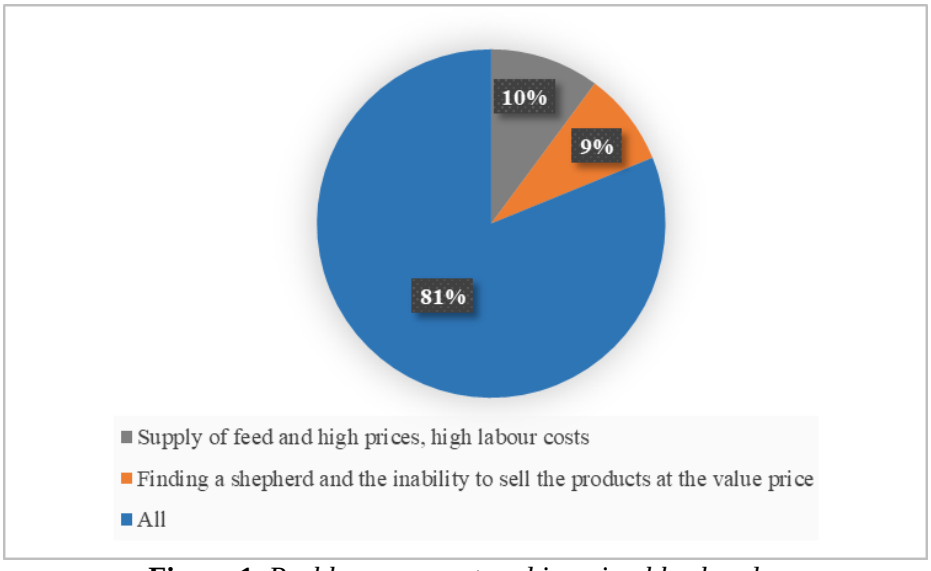

Figure 1. *Problems encountered in animal husbandry*

Percent 81 of the breeders reported that they experienced more than one problem (Figure 1.). These problems can be listed as difficulties in the supply of feed and high prices, high labour costs, the problem of finding a shepherd and the inability to sell the products at their value. The rate of those who receive government support and bank credit support from agricultural supports is 70.9%. Among the production problems identified in the study, feed supply and high feed prices are similar to the problems reported by Karadaş (2018) in Hakkari and Savaş et al. (2019a) in Igdir province and Ceyhan et al. (2020) in their study.

CONCLUSION

As a result of the study, it was determined that nomadic sheep breeders keep records and pay attention to disinfection practices. It was determined that the most common problems experienced by the breeders were the difficulty in obtaining feed and finding a shepherd, high feed prices and lab costs, and the inability to market the products at value prices. It was determined that milking was not practiced on the sheep farms where the study was conducted. All of the milk is used for raising lambs. Sheep milk is a very valuable product. Training and support activities should be carried out to bring this product into the economy. The geographical structure and climate of the Black Sea region are suitable for small ruminants production. It is important for the sustainability of animal husbandry to inform the breeders, provide practical training, and consider sheep production and other animal husbandry activities as a line of business within the scope of health insurance coverage. As a result of the study, it was determined that the breeders were aged 40 and above. More work should be done to direct young people towards animal husbandry. In the study, the number of members of agricultural support organizations is high. However, it would be useful to ensure that the breeders are informed about agricultural support organizations in general.

It should be taken into consideration that many environmental factors have an impact on nomadic sheep production. For the breeders to continue sheep production, it is important to facilitate transportation procedures and find a shepherd. As a result of the study, it can be said that nomadic sheep production continues with traditional methods. The problems of nomadic sheep breeders can be reduced with agricultural supports, health protection methods, early disease diagnosis and pasture grazing order and training.

CONFLICT OF INTEREST

The authors declare no conflict of interest in the study.

AUTHORS CONTRIBUTION

All authors contributed equally.

ETHİCAL STATEMENT

During the writing process of the study titled "**Socio-Economic Structure, Production Practices, Observations and Suggestions in Nomadic Sheep Production in Ordu province located in Black-Sea Region of Türkiye**", scientific rules, ethical and citation rules were followed; No falsification has been made on the collected data and this study has not been sent to any other academic media for evaluation. Permission to conduct the study was obtained with the decision of the Ordu University Social Sciences and Humanities Research Ethics Committee dated March 2, 2023 and numbered 2023-35

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Research Article

Examination of Mandible in Morkaraman Sheep Using Geometric Morphometry Method

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ABSTRACT

The aim of this study is to examine and analyze the mandible of Morkaraman sheep without any skeletal disorders using the geometric morphometric method. For this purpose, a total of 14 mandibles from male and female individuals were used in the study. The main components in multidimensional data sets were determined with Principal Component Analysis, used within the scope of the geometric morphometry method, and the differences between the samples were determined with Discriminant Function Analysis. Statistical and formal analyzes of these variances were also performed. A total of 12 principal components were obtained with 12 punctuations selected on a total of 14 mandibular (7 female, 7 male) images. Among these principal components, the first principal component (PC1) alone accounted for 30.409% of the total variation. The second principal component (PC2) alone accounted for 22.265% of the total variation, and the third principal component (PC3) alone accounted for 14.893% of the total variation. The first three of the variances obtained explained 67,567 of the shape differences. Discriminant Function Analysis (DFA) was used to objectively evaluate gender differences. In the discriminant function analysis, the p value was above 0.05 (p = 0.7). Although there was a complete separation between genders formally and statistically, no significant p value was obtained. In line with these analyses, information was obtained about the anatomical features and adaptations of the Morkaraman sheep mandible, which is one of the important economic resources of our country and is bred in a wide area, and it has become an exemplary study in this field.

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INTRODUCTION

In the Eastern Anatolia Region, which has the majority of our sheep existence; Morkaraman breed is widely bred in Erzurum, and Karakaş sheep, a variety of Akkaraman breed, is widely bred in Bitlis and Van regions (Karaca et al., 1996). Again, Tuj is grown in Kars and Hamdani is grown in the southern parts of the region (Geliyi and İlaslan, 1978).

Morkaraman breed constitutes 21.5% of our existing sheep. This breed is grown in a wide region from the east of Sivas and Malatya provinces to Kars and Van. However, it is mostly grown in the provinces of Erzurum, Van, Ağrı, Kars and Muş. Sheep wealth in the Eastern Anatolia region constitutes 30.6% of Türkiye's sheep wealth. Morkaraman breed sheep constitute 61.1% of the sheep population in the Eastern Anatolia region. As a result of the research, the ram breeding of the Morkaraman sheep breed is generally done in September and October; Its birth takes place in February and March. Its morphological characteristics are: withers height 70 cm, back height 68 cm, rump height 69 cm, body length 65 cm, chest width 18 cm, front rump width 18.5 cm, middle rump width 21 cm, front shin circumference 7.4 cm, rear shin circumference. It was reported as 9 cm, leg height as 38.7 cm, head length and width as 22.4 cm, and 12.5 cm, and ear length as 14.7 cm, (Kayalık and Bingöl, 2015).

The geometric morphometric method, which measures the position differences of objects and the amount of shape changes, determines the shape differences according to the sign coordinates (Kimmerle et al. 2008). Markings are made on the figures with homologous landmarks. Semilandmarks allow the measurement of two- or three-dimensional homologous curves and surfaces and their analysis together with traditional marks (Gunz and Mitteroecker 2013).

The lower jaw is considered one of the strongest skull bones for sex determination and has therefore been one of the most studied bones. It accurately reflects gender characteristics (Okkesim and Erhamza 2020).

Studies conducted on many different species and races using traditional morphometric methods are widely available in the literature (Dalga et al. 2021; Dalga et al. 2022; Özcan et al. 2010; Karimi et al. 2011; Mohamed et al. 2016; Dalga et al. 2017; Dalga et al.2018; Dalga and Aslan 2020; Wehausen and Ramey 2000; Dalga and Aslan 2021; Dalga 2020; Jashari et al. 2022; Gundemir et al. 2020; Yılmaz and Demircioğlu 2020; Özüdoğru et al. 2019). In addition to examining evolutionary processes, there are many studies that analyze two- and three-dimensional images using the geometric morphometry method (Klingenberg and Marugan 2013; Szara et al. 2022; Koçak et al. 2023; Pares 2015; Fernandez et al. 2023).

This study was conducted to reveal the shape differences of the mandible between male and female individuals in Morkaraman sheep, using analyzes based on the geometric morphometry method.

MATERIAL AND METHODS

In the study, the mandible of the Morkaraman sheep, which is located in the Eastern Anatolia region and bred in Kars, Ardahan and Iğdır provinces, was used. A total of 14 mandibles (7F/7M) were obtained from slaughterhouses in the relevant provinces. The number was found sufficient for parametric analyzes in terms of gender. The study permit for animal experiments was approved by the local ethics committee unit with reference code 2023/071. Mandibles were first separated from the skull. Then, the muscles on it were dissected. Boiling was applied to thoroughly remove the muscles. After the boiling process, the mandibles were kept in hydrogen peroxide for 20-30 minutes and the mandibles were whitened. After the drying process, the mandibles were photographed from the same distance (15 cm,). The left lateral sides of the mandibles were used for photography. For punctuation, photographs were saved as tps files using tpsUtil (version 1.82). The tps file was imported into the tpsDig (version 2.31) program for marking. Marking was made with 12 selected points on each mandible using the TpsDig program. Each mandible photograph was marked at the same locations. The marked mandible data were converted to text file and imported into the MorphoJ (version 1.07a) program to perform geometric morphometric analysis. Principal Component Analysis (PCA) was performed and shape variations were obtained. Each component was ranked by percentage of variation. Additionally, Discriminant Function Analysis (DFA) was

performed and shape variations were obtained. The distinction between male and female groups was examined statistically and formally with Discriminant Function Analysis.

RESULTS

A total of 12 principal components were obtained with 12 punctuations selected on 14 mandible (7 female, 7 male) images of Morkaraman sheep (Figure 1). Among these principal components, the first principal component (PC1) alone accounts for 30.409% of the total variation. The second principal component (PC2) alone accounts for 22.265% of the total variation, and the third principal component (PC3) alone accounts for 14.893% of the total variation. Data from PCA are presented in Table 1.

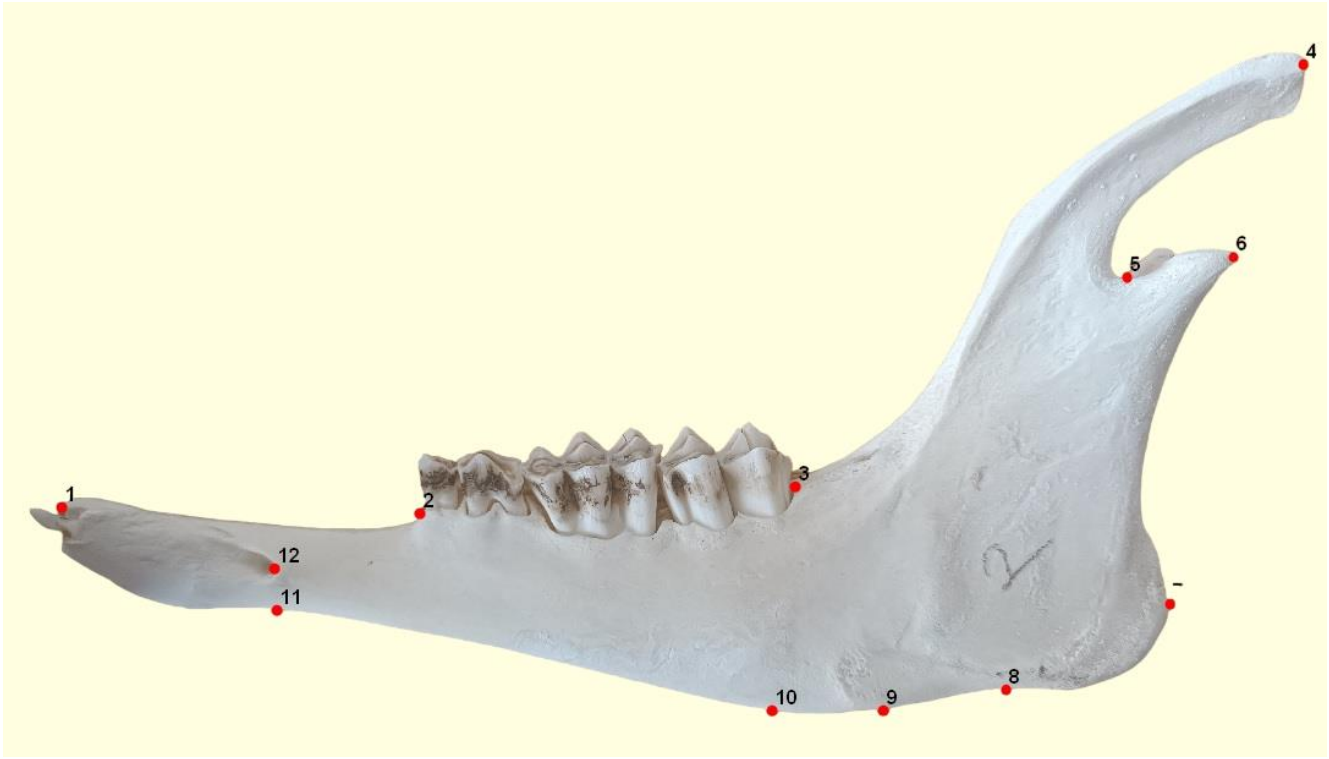

Figure 1: *The Landmarks point of on Mandible; 1: İnfradentale, 2: First premolar teet oral border, 3: Last molar teet aboral border, 4: Processus coronoideus, 5: İncisura mandibulae, 6: Processus condylaris, 7: Caudal end point, 8: İncisura vasorum facialum, 9: Ventral point, 10: the length of from molar teeth to ventral border, 11: the ventral point of under diastema, 12: Foramen mentale*

Table 1: *Eigenvalues and variances obtained as a result of principal component analysis*

PC No	Eigenvalues	Varyans(%)	PC No	Eigenvalues	Varyans (%)
PC1	0,00054645	30,409	**PC7**	0,00005990	3,334
PC2	0,00040009	22,265	**PC8**	0,00005671	3,156
PC3	0,00026763	14,893	**PC9**	0,00003081	1,715
PC4	0,00022065	12,279	**PC10**	0,00001543	0,859
PC5	0,00010948	6,093	**PC11**	0,00000567	0,316
PC6	0,00008056	4,483	**PC12**	0,00000360	0,200

Figure 2 shows both cumulative and individual variation distribution plots for 12 of the principal component analyses. As can be seen from the graph, PC1, PC2 and PC3 cumulatively account for more than half of the total variation. Additionally, these three variations individually have significant variation

percentages. With these findings, PC1, PC2 and PC3 were compared while performing principal component analysis.

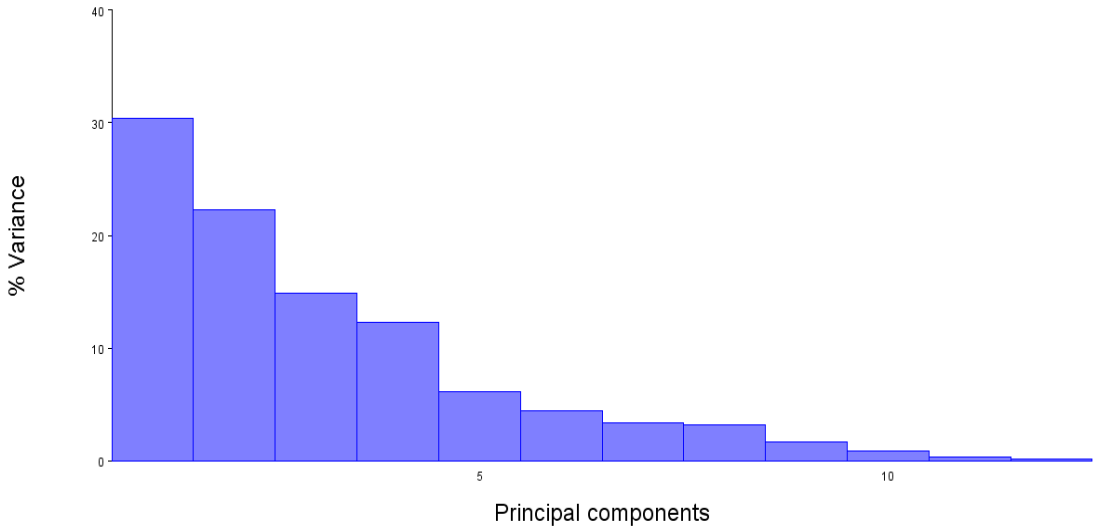

Figure 2: *Variation distribution plot of principal component analysis*

The shape variation for PC1, PC2 and PC3 is shown in Figure 3. Dots represent the average shape. The extensions represent the positive limit for PC1, PC2 and PC3. For PC1, it narrows infradentally, distally and medially, while for PC2 and PC3, it widens proximally. For PC1, the first premolar teet oral border expanded proximally, while for PC2 and PC3 it expanded distally. For PC1, PC2 and PC3, the last molar teet aboral border has expanded distally. For PC1, the processus coronodieus expanded proximally, while in PC2 and PC3 it expanded distally. For PC1, the incisura mandibulae expanded proximally, while in PC2 and PC3 it expanded distally. For PC1, the processus condylaris expanded proximally, while in PC2 and PC3 it expanded distally. While the caudal end point expanded distally for PC1, it expanded proximally for PC2 and PC3. For PC1 and PC3, the incisura vasorum facialum expanded distally, while for PC2 it expanded proximally. For PC1 and PC3, the ventral end point expanded distally, while for PC2 it expanded proximally. For PC1, the distance of the molar teeth to the ventral edge expanded proximally, while in PC2 and PC3 it expanded distally. For PC1, the distance of the premolar to the ventral edge narrows medially, while for PC2 it widens distally. For PC3, it expanded proximally. For PC1, the mental foramen expanded proximally, while for PC2 it expanded distally, and for PC3 it expanded proximally. As a result of the statistical and formal analysis of the Morkaraman sheep mandible, it was obtained that the formal variation in the distal region was higher than in other regions.

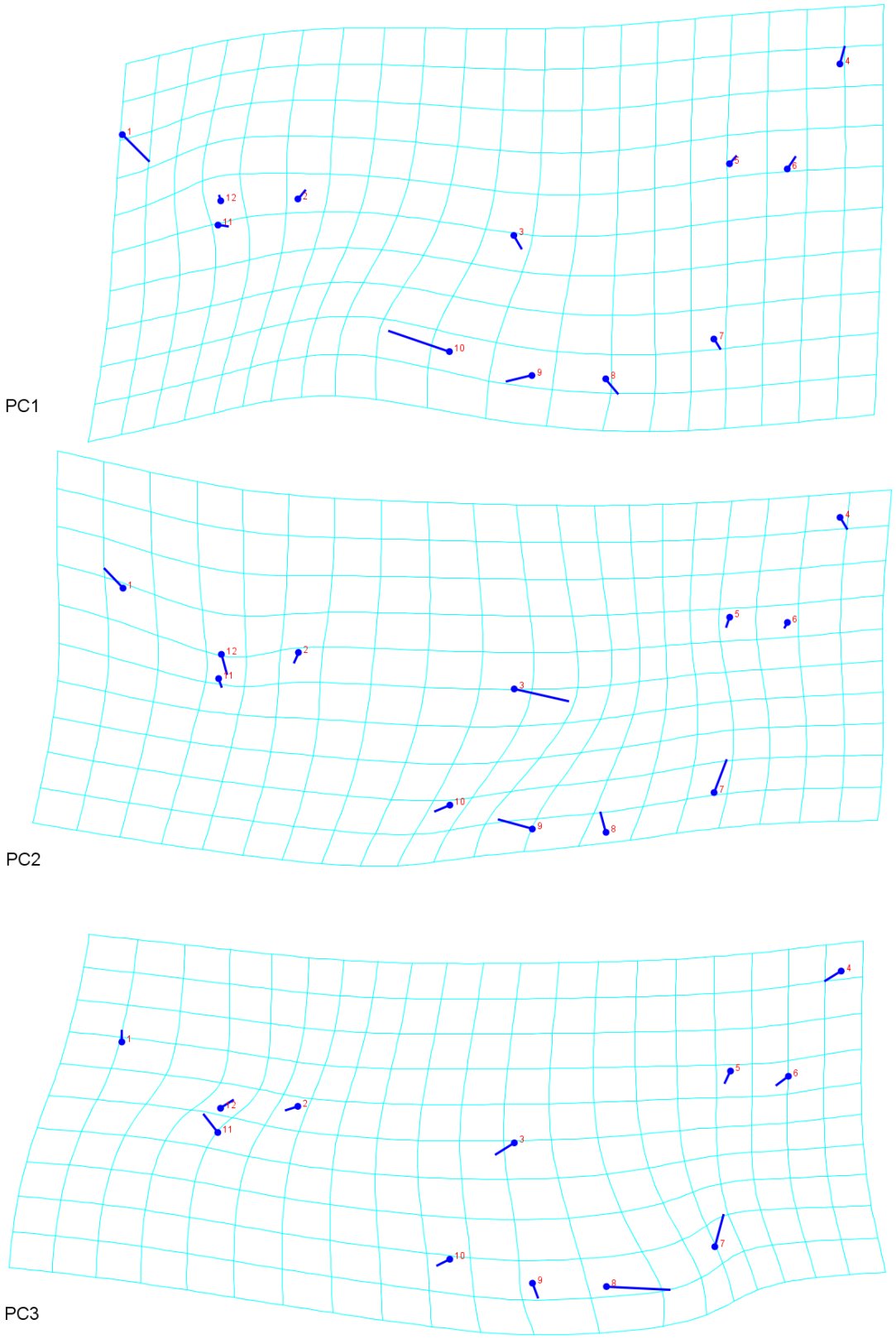

Figure 3: *1: İnfradentale, 2: First premolar teet oral border, 3: Last molar teet aboral border, 4: Processus coronoideus, 5: İncisura mandibulae, 6: Processus condylaris, 7: Caudal end point, 8: İncisura vaorum facialum, 9: Ventral point, 10: the length of from molar teeth to ventral border, 11: the ventral point of under diastema, 12: Mental foramen*

A total of 12 principal components were obtained in the Principal component analysis in figures 4 and 5. The first three principal components (PC1, PC2 and PC3) explained 30.409, 22.265 and 14.893% of the total variance, respectively.

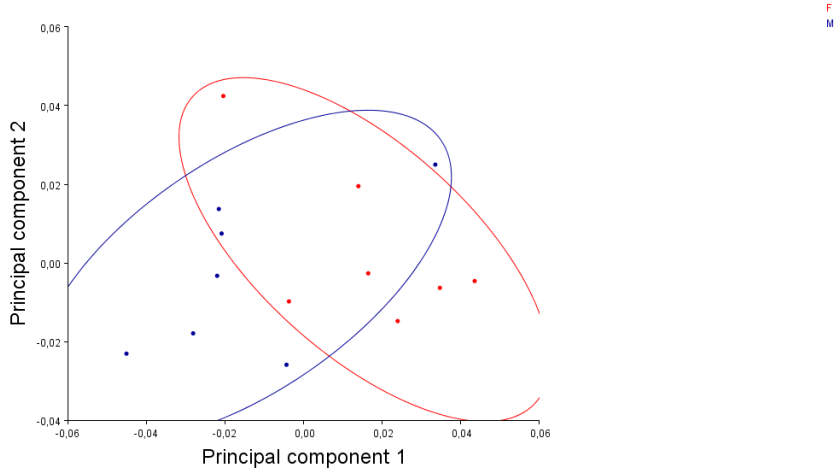

***Figure 4**: Morkaraman sheep Principal component 1-2 variation distributions and 95% confidence ellipses. Red dots are female, green dots are male.*

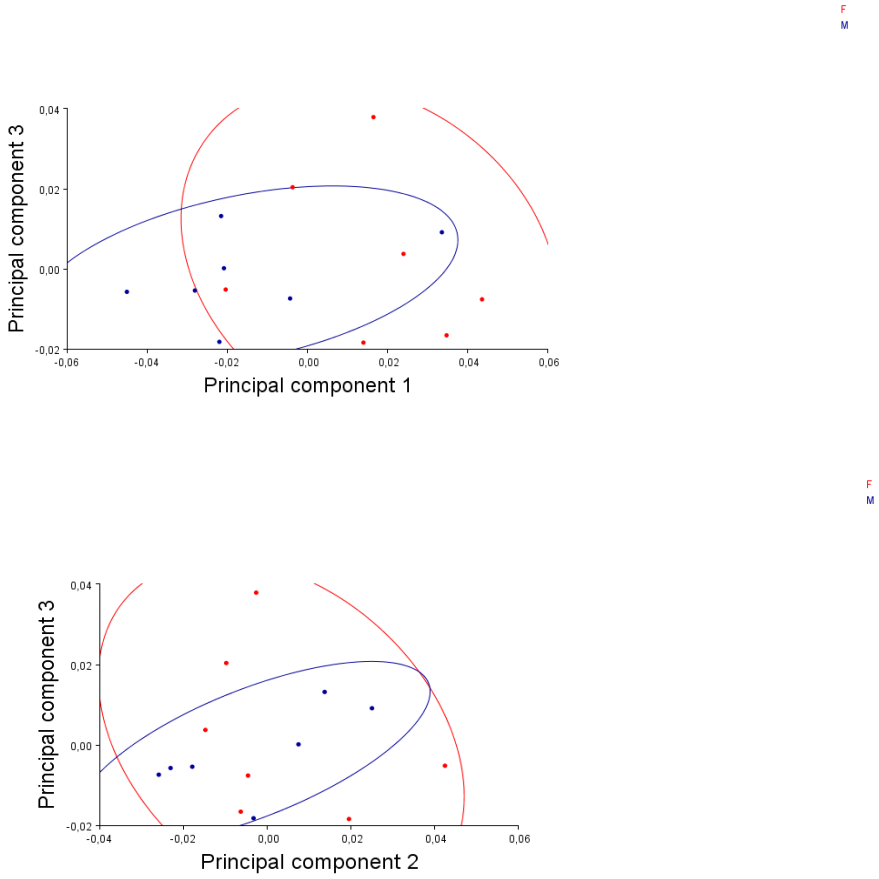

Figure 5: *Morkaraman sheep Principal component 1-3 and 2-3 variation distributions and 95% confidence ellipses. Red dots are female, green dots are male.*

Discriminant Function Analysis (DFA) was used to objectively evaluate gender differences. In the discriminant function analysis, the p value was above 0.05 (p = 0.7). Although there was a complete separation between genders formally and statistically, no significant p value was found.

In Figure 6, there are points that show significant changes in shape as the variation from female to male increases. The first premolar teet oral border has expanded proximally. The last molar teet aboral border has expanded ventrally. Processus coronoideus has expanded distally. The caudal end point narrows proximally. Incicura vasorum facialum is narrowed proximally. The distance of the molar teeth to the ventral edge has increased distally. Foramen mentale has expanded ventrally.

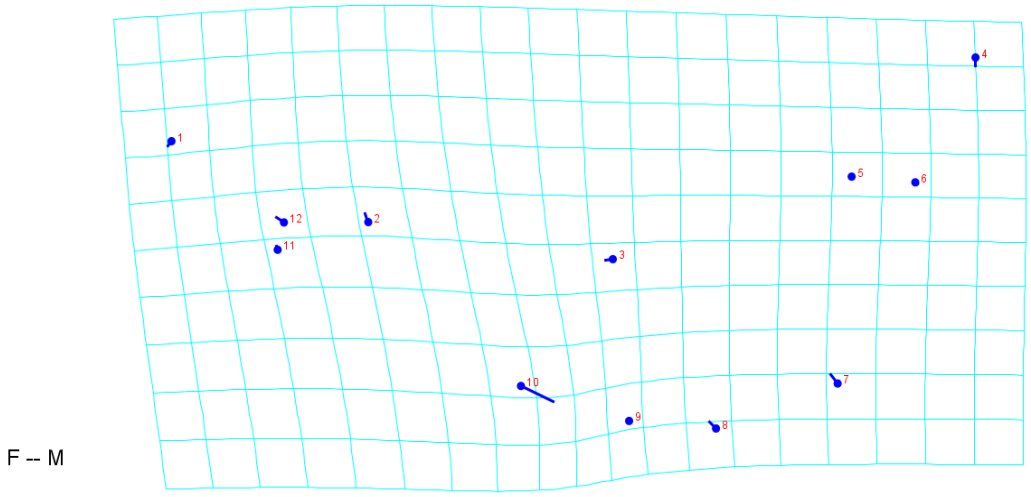

Figure 6: *Differences between males and females are shown with punctuation. While the round dots represent females, the extensions coming from the dots represent males.*

Discriminant Function Analysis (DFA) was performed on the mandibles of Morkaraman sheep for gender determination. The variance and frequency distribution of individuals is given in Figure 7. It can be seen that the male and female groups are completely separated from each other.

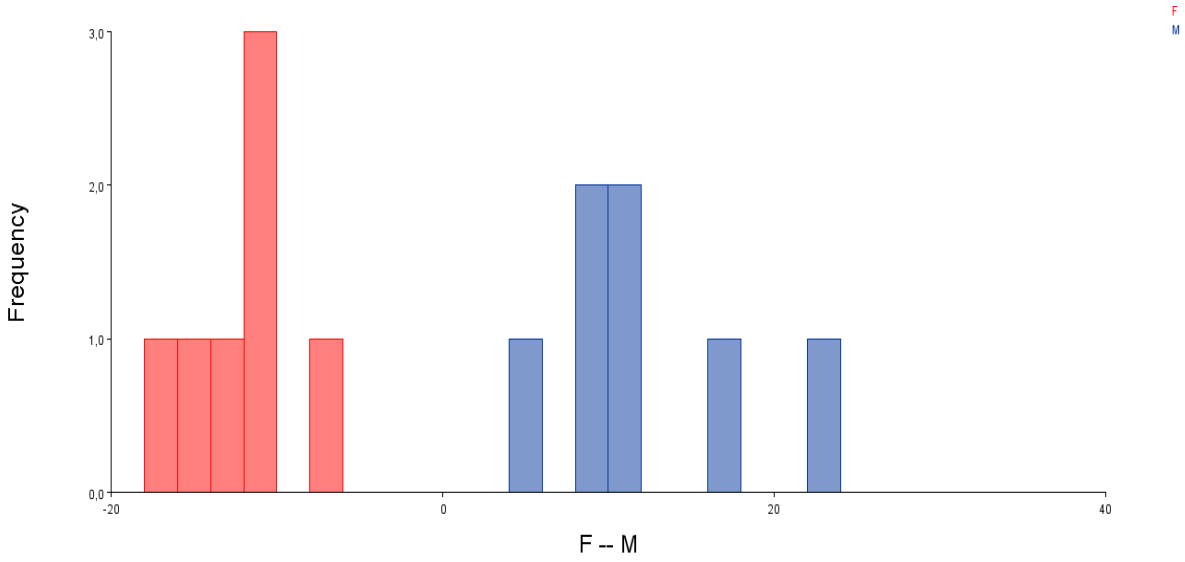

Figure 7: *Gender distribution graph in Discriminant Function Analysis. Red ones are female, green ones are male.*

DISCUSSION

In this study, 14 (7F/7M) mandibles from Morkaraman sheep were used. Morkaraman sheep mandibles were marked from 12 points and both Principal Component Analysis and Discriminant Function analyzes were performed with geometric morphometric analysis. Morkaraman sheep mandible was examined for gender determination. Geometric morphometry was an important method that should be used to distinguish gender between Morkaraman sheep mandibles. In our study, although there was no separation between the genders in the Principal Component Analysis, a complete formal separation was observed between the genders in the Discriminate Function Analysis.

Geometric morphometric method-based analyzes performed on the skulls and mandibles of mammals are used to explain the phylogenetic relationships between living things (Marcus et al. 2000). In addition to skull studies in ruminants, where dimorphism is clearly evident, various researchers have also conducted studies on the lower jaw bone and contributed the data to the literature (Özkan et al. 2020).

Analyzes were made on the lengths determined by studies on the skull (Jashari et al. 2022), mandible (Jashari et al. 2022; Özkan et al. 2020) and metapodium (Gündemir et al. 2020; Kahraman et al. 2022) in sheep, and our As in our study, the unique anatomical differences of the species were evaluated with various methods in terms of species and gender. With simpler variation and deviation analyses, the effects of variables on gender were examined in morkaraman sheep.

There are many studies in the literature in which the obtained principal component variances, especially the first three, are evaluated and discussed as a result of the analysis. In such a study conducted on the mandible of Awassi sheep, researchers stated that especially the first principal component explained 24.92% of the total shape difference (Demircioğlu et al. 2021). Examining the variations in different sheep breeds using the geometric morphometry method, Boz et al. (2023) obtained a total of 14 components. In the components they obtained, they stated that PC1 explained 29.668% of the total variation and PC2 explained 22.169%, and both PC values explained more than half of the total variation. They also reported 13.643% in PC3. In Morkaraman sheep (PC1), it alone explained 30.409% of the total variation. PC2 and PC3 explained 22.265% and 14.893% respectively. Demiraslan et al. (2024), who examined the mandible of Hamdani and Awasi sheep using the geometric morphometric method, stated that, according to their findings, PC1 explained 36.52% of the total difference, and the sum of the other two PC analyzes and PC1 explained 63.822% of the shape difference. In Morkaraman sheep, the sum of PC1 and PC2 alone explained more than half of the shape variation.

Demiraslan et al. (2021), conducted geometric morphometric analysis on the mandibles of Honamlı and Kıl goats. They reported in their study that hair goats showed a very distinct gender difference compared to honamlı goats. They also stated that in terms of race, male goats are clearly clustered compared to females. Demircioğlu et al. (2021) also stated that there was no significant difference between genders between mandibles.

Researchers who studied Anatolian wild sheep (Yalçın and Kaya, 2009) and Awassi sheep (Demircioğlu et al. 2021) reported that no dimorphism was observed in terms of gender. In our study, when we compared the study with other studies in the literature in terms of gender dimorphism, similar findings were obtained. However, when we looked at it in terms of discriminant function analysis, formal differences were observed.

Principal component variances, which express statistical and shape variations between groups, are related to the number of materials used, Koçak et al. (2023) obtained 46 variances in their principal component analysis study, whereas in our study, 12 variances were obtained due to the difference in the number of animals. Like the researchers who discriminate between genders with discriminant function analysis (Koçak et al. 2023), this method was used in our study and there was a complete separation between genders.

Researchers who studied the Anatolian wild sheep (Yalçın and Kaya 2009), in which the shape variations in the gonion ventrale are quite prominent, suggested that this difference is related to environmental conditions and nutrition, and also due to adaptations during the domestication process. Among the first three analyzes obtained

in Morkaraman sheep, it is seen that the gonion ventrale expands distally in PC1 and PC3, and proximally in PC2. It has been reported that there are significant differences in this parameter in Awassi sheep (24). It was also stated that there were differences in LM2, LM8 and LM10 levels, but they were limited.

CONCLUSION

This study aims to analyze the morphometric findings of the Morkaraman sheep mandible as well as its shape, and it is thought that these analyzes will contribute significantly to the studies to be carried out in this field, the identification and determination of osteological materials obtained as a result of archaeological excavations, the creation of three-dimensional models and the use of these shape analyzes in animal human models. In addition, principal component variation values between males and females were examined on a race basis with Principal Component Analysis, and shape changes between males and females were interpreted in Principal Component Analysis. In addition, gender determination was evaluated with Discriminant Function Analysis, which is the main element of the study.

CONFLICT OF INTEREST

The authors have declared no conflicts of interest.

AUTHORS CONTRIBUTION

SD and SK designed the study. SD, and SK performed the geometrical and morphometric analysis. SD and SK carried out the statistical analysis. SD and SK the imaging all section. The manuscript was written by SD and SK. All authors approved the final version.

ETHICAL STATEMENT

During the writing process of the study titled "**Examination of Mandible in Morkaraman Sheep Using Geometric Morphometry method**", scientific rules, ethical and citation rules were followed; No falsification has been made on the collected data and this study has not been sent to any other academic media for evaluation. The study protocol was approved by the Ethics Committee Kafkas University (20.06.2023, KAU/HADYEK-2023/07).

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Research Article

Kıvırcık Koyunlarında Bulbus Oculi'nin Morfometrik ve Makroanatomik Olarak İncelenmesi

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ÖZET

MAKALE BİLGİSİ

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Çalışmada kıvırcık koyunlarında bulbus oculi'nin morfometrik ve makroanatomik olarak incelenmesi amaçlanmıştır. Bu amaçla Balıkesir'de mezbehanede kesilen 8 adet kıvırcık koyun kafası kullanıldı. Kafalar bütün halinde tartıldıktan sonra bulbus oculi'ler orbitadan diseke edildi ve sonra hassas terazi ile ağırlıkları saptandı. Daha sonra pupilla, lens, bulbus oculi ve cornea'ya ait 11 noktadan ölçümler yapıldı. Bulbus oculi'ye ait morfometrik analizler IBM®SPSS 22 paket programında yapılmıştır. Cinsiyet ile anatomik yapının sağ ve sol taraflarına ait ölçülerin verileri arasında istatistiksel fark olup olmadığı ve cinsiyet ile organların sağ ile sol olmasının birbirini etkileyip etkilemediği ve aralarında etkileşimin olup olmadığı çok faktörlü ve etkileşimli varyans analizi (Two-Way ANOVA) uygulandı. Kafa ağırlığının cinsiyet ayrımına göre analizi Mann Whitney U testi ile incelendi. İncelenen tüm özellikler (uzunluklar ve kalınlıklar) arasında bir ilişkinin istatistiksel olarak anlamlı varlığı ise Pearson korelasyon testiyle incelendi ve İstatistiksel anlamlılık düzeyi $P \leq 0,05$ olarak kabul edildi. Yapılan analizler sonucu istatiksel olarak organların cinsiyet ile ilgili olarak sağ ve sol olmasının birbirini etkilemediği sonucuna varılmıştır. Korelasyon analizinde ise anlamlı bir ilişki olduğu görülmüştür.

Anahtar kelimeler: *Kıvırcık koyunu, morfometri, bulbus oculi.*

Morphometric and Macroanatomic Investigation of Bulbus Oculi in Kıvırcık Sheep

ABSTRACT

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In this study, it was aimed to examine the bulbus oculi morphometrically and macroanatomically in kıvırcık sheep. For this purpose, 8 curly sheep heads cut in a slaughterhouse in Balıkesir were used. After the heads were weighed as a whole, the bulbus oculi were dissected from the orbit, and then their weights were determined with precision balances. Then, measurements were made from 11 points belonging to the pupil, lens, bulbus oculi and cornea. Morphometric analyzes of bulbus oculi were made in IBM®SPSS 22 package program. Multi-factor and interactive analysis of variance (Two-Way ANOVA) test was used to determine whether there was a statistical difference between gender and the data of the measurements of the right and left sides of the anatomical structure, and whether the gender and the right and left sides of the organs affected each other and whether there was an interaction between them. Analysis of head weight according to gender was analyzed by Mann Whitney U test. The presence of a statistically significant relationship between all examined features (lengths and thicknesses) was examined with the Pearson correlation test and the statistical significance level was accepted as $P \leq 0.05$. As a result of the analyzes, it was concluded that statistically the right and left organs in relation to gender do not affect each other. In the correlation analysis, it was seen that there was a significant relationship.

Keywords: *Kıvırcık sheep, morphometry, bulbus oculi.*

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GİRİŞ

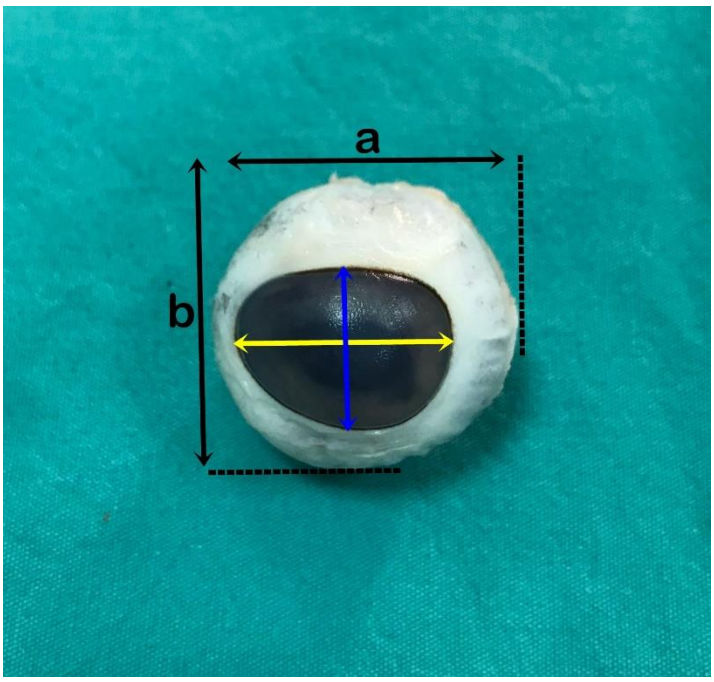
Kıvırcık koyunu Türkiye, Bulgaristan ve Yunanistan'da yetiştirilen bir koyun ırkıdır. Türkiye'deki yağsız uzun kuyruklu bir ırk olan kıvırcık koyununun, diğer koyun ırkları ile karşılaştırıldığında yapağı kalitesinin yüksek olduğu bildirilmiştir. Türkiye'de yetiştirilmekte olan Kıvırcık koyunları da kaba, karışık yapağı ve beyaz vücutlarıyla tanınmaktadırlar. Ülkemizde ise en çok Bursa, Balıkesir, Sakarya, Manisa, İzmir, Aydın ve Trakya bölgesinde yetiştirilmektedir (Selvi ve Üstüner 2021). Baş ve ayaklarında siyah lekeli alanlar görülebilir. Erkek hayvanlarda beyaz renkli spiral şeklinde boynuzlar bulunurken dişi hayvanların boynuzları yoktur. Baş, boyun, karın altı, bacaklar çıplaktır. Kuyruk ise uzun, ince ve tarsal ekleme kadar uzanır (Selvi, ve Üstüner 2021; Kaymakçı ve Sönmez, 1992). Kıvırcık ırkında, yağ et lifleri arasında iyi dağıldığı için et kalitesi yönünden yerli koyun ırklarında ilk sırada bulunmaktadır (Akçapınar, 1994). Canlılar için hayati bir organ olan göz, temel duyu yeteneklerinden olan görme yeteneğini yerine getirebilmektedir. Bu amaçla birçok çevresel faktör ile birlikte zaman içerisinde canlının yaşadığı ortama da adapte olabilmesi için şekillerinde bazı farklılaşmalar meydana gelmiştir. Görme organı olan göz, çevreden foto stimülatörleri toplayıp, kaydeden ve tüm bunları anatomik ve fizyolojik mekanizmaları beyne ileterek elektriksel uyarılara dönüştüren birçok bölümden oluşmuştur (König ve Liebich, 2013). Göz; duyu organları içerisinden dış etmenlere, hastalıklara ve ışığa karşı duyarlı olan vücudun en kompleks organıdır (Demircioğlu ve Yılmaz, 2019). Bulbus oculi, şekil ve büyüklük yönünden türler ve bireyler arasında net görülebilen değişkenlere sahiptir (König ve Liebich, 2013). Memelilerde kalın bir küresel hat olarak bulunan göz küresi, koyun, domuz, at ve sığırlarda anterio-posterior axiste hafif basık ve düzleşmiş olarak bulunur (Okşar ve ark., 2021). Bulbus oculi'nin anatomik olarak yer aldığı bölge hayvanlarda av ya da avcı olduklarını gösterebilir. Avcı olarak bilinen kedi, köpek gibi carnivorlarda gözler ön ve ileride bulunurken, av olarak tanımlanabilecek olan otçul hayvanlar ve geviş getirenlerde gözler lateral olarak yer alır. Bu türlerin sağ ve sol taraftaki görüntüleri birbiriyle örtüşmez, binoküler görme kapasiteleri azdır (Dyce ve ark., 2010).Bulbus oculi, orbita ismi verilen anatomik yapının içinde yer almaktadır (Akın ve Samsar, 1999). Türler ve bireyleri arasında bulbus oculi'nin şekil ve büyüklük açısından gözle görülebilir farklılaşmalar bulunmaktadır. Kornea'nın öne doğru taştığı kısma oranla daha büyük bir eğrilik gösteren arka bölüm nedeni ile göz küresinin dış cidarı tamamen yuvarlak değildir (König ve Liebich, 2013). Bulbus oculi, dıştan içe doğru; tunica fibrosa bulbi, tunica vasculosa bulbi, tunica interna bulbi olmak üzere üç katmandan oluşmaktadır. Tunica fibrosa bulbi'de cornea ve sclera, tunica vasculosa bulbi'de iris, corpus cliare ve choroidea, tunica interna bulbi'de ise retina bulunur (Dursun, 2000; Malkoç, 2006).

MATERYAL VE YÖNTEM

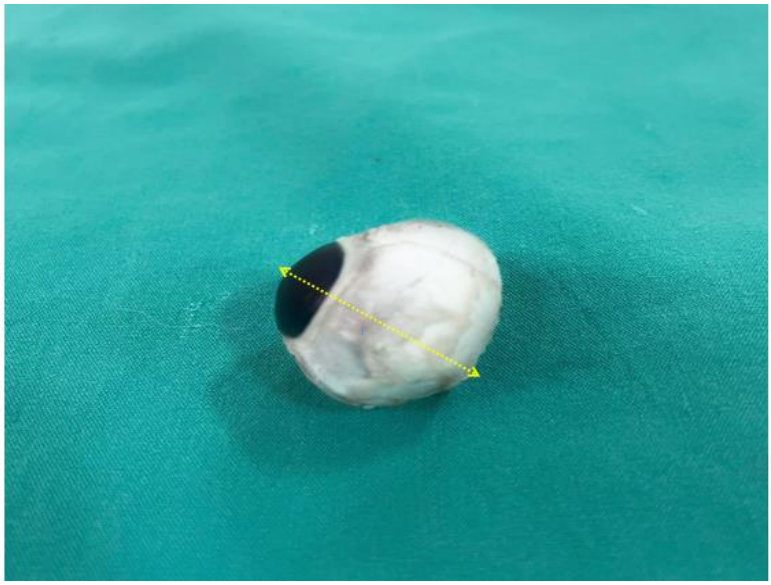
Bu çalışmada 8 adet Kıvırcık koyununa ait 16 adet bulbus oculi incelenmiştir. Materyaller Balıkesir'de mezbehanede kesilen Kıvırcık ırkı koyunlarından temin edildi. Kullanılacak olan bulbus oculi'lerin deforme olmamış, normal görünümlü olmasına dikkat edildi. Bir bütün olarak alınan kafa bölgesi, Balıkesir Üniversitesi Veteriner Fakültesi Anatomi Laboratuvarına getirildi. Kafalar bütün halinde tartıldıktan sonra bulbus oculi'ler orbitadan diseke edildikten sonra hassas terazi ile ağırlıkları saptandı. Daha sonra pupilla, lens, bulbus oculi ve cornea'ya ait 11 noktadan ölçümler yapıldı. Ölçüm noktaları Demircioğlu ve Yılmaz (2019)'a göre belirlendi. Ölçümler Piranha marka dijital kumpas yardımıyla ölçüldü. Analizler IBM®SPSS 22 paket programında yapılmıştır.

Bulbus oculi'ye ait ölçüm noktaları

a. Dorso-ventral (DV) çap: Bulbus oculi'nin dorsal yönde en uç noktası ile ventral yöndeki en uç noktaları arasındaki uzunluk
b. Medio-lateral (ML) çap: Bulbus oculi'nin temporal ve nasal taraftaki uç noktaları arasındaki uzunluk
c. Axial uzunluk/çap: Polus anterior ile polus posterior arasındaki uzunluk



Şekil 1. *Bulbus oculi ve cornea'ya ait ölçüm noktaları. a: Bulbus oculinin ML çapı, b: Bulbus oculinin DV çapı, Sarı ok: Cornea'nın ML çapı, Mavi ok: Cornea'nın DV çapı.*



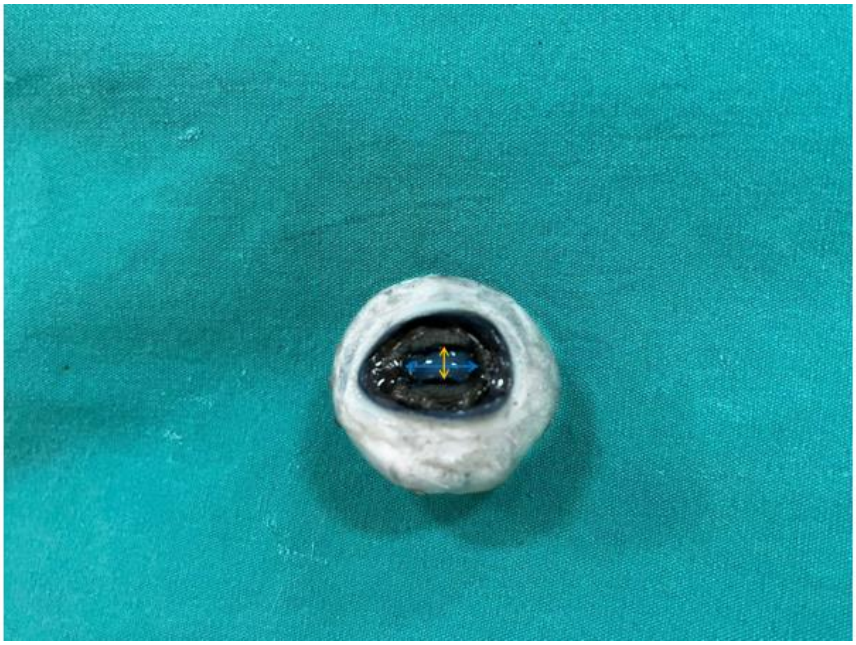
Şekil 2. *Bulbus oculi'nin axial çapı.*

Cornea'ya ait ölçüm noktaları

a. Dorso-ventral (DV) çap: Corne'nın dorsal yönde en uç noktası ile ventral yöndeki uç noktaları arasındaki uzunluk
b. Medio-lateral (ML) çap: Cornea'nın temporal ve nasal taraftaki uç noktaları arasındaki uzunluk

Pupilla'ya ait ölçüm noktaları

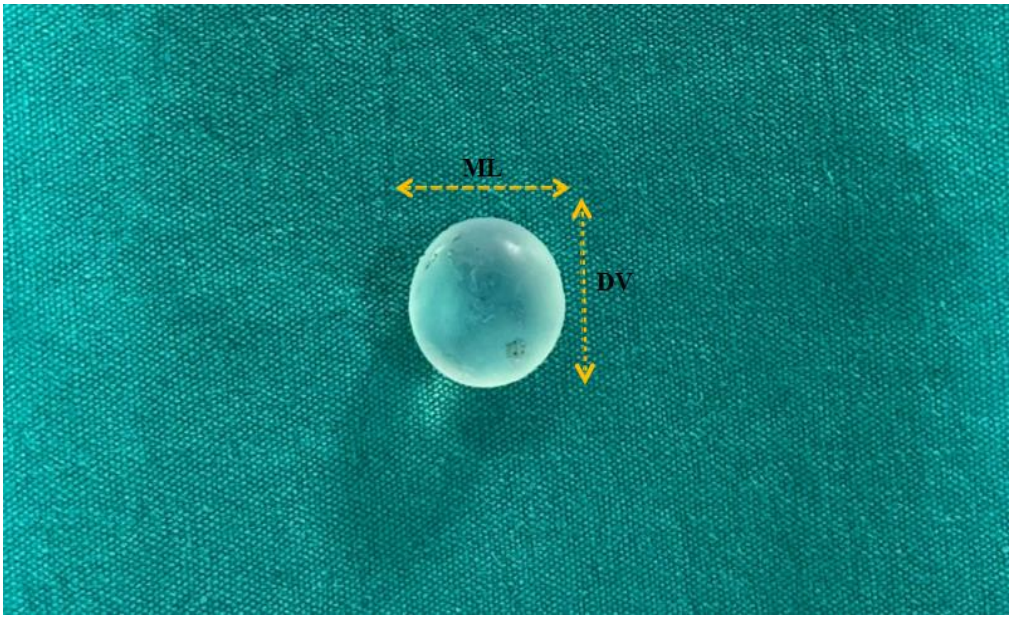
a. Dorso-ventral (DV) çap: Pupilla'nın dorsal yönde en uç noktası ile ventral yöndeki uç noktaları arasındaki uzunluk
b. Medio-lateral (ML) çap: Pupilla'nın temporal ve nasal taraftaki uç noktaları arasındaki uzunluk



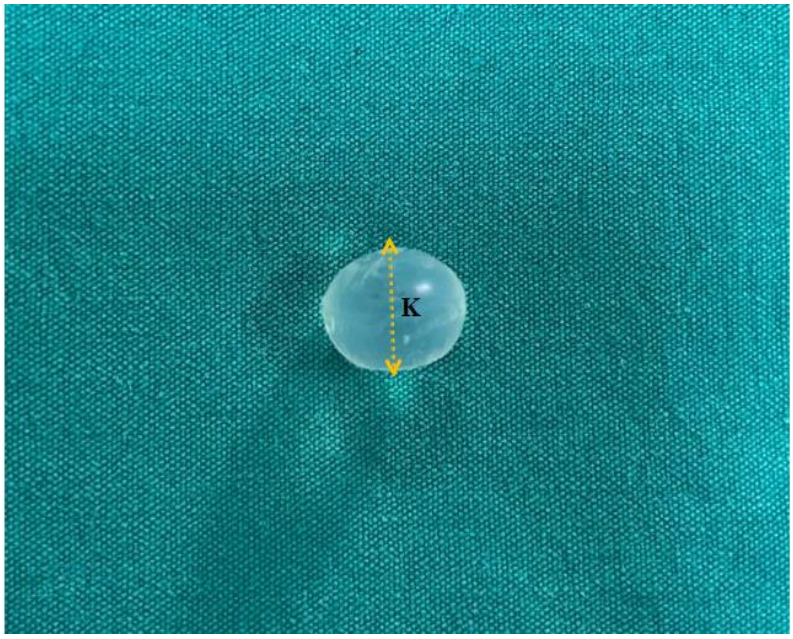
Şekil 3. *Pupilla'ya ait ölçüm noktaları, mavi ok: Pupilla'nın ML çapı, sarı ok: Pupilla'nın DV çapı.*

Lens'e ait ölçüm noktaları

a. Dorso-ventral (DV) çap: Lensin dorsal yönde en uç noktası ile ventral yöndeki uç noktaları arasındaki uzunluk
b. Medio-lateral (ML) çap: Lensin temporal ve nasal taraftaki uç noktaları arasındaki uzunluk
c. Kalınlık: Lensin orta noktasının anterior ve posterior uç noktaları arasındaki uzunluk.



Şekil 4. *Lense ait ölçüm noktaları. ML: Lensin ML çapı, DV: Lensin DV çapı*



Şekil 5. *K: Lensin kalınlığı.*

BULGULAR

Bulbus oculiye ait morfometrik değerler Tablo 1' de gösterilmiştir. Cinsiyet ile anatomik yapının sağ ve sol taraflarına ait ölçülerin verileri arasında istatistiksel fark olup olmadığı ve cinsiyet ile organların sağ ile sol olmasının birbirini etkileyip etkilemediği ve aralarında etkileşimin olup olmadığı çok faktörlü ve etkileşimli varyans analizi (Two-Way ANOVA) testiyle incelenmiştir. Bu analizler Tablo 2-4'te gösterilmiştir. Kafa ağırlığının cinsiyet ayrımına göre analizi Mann Whitney U testi ile incelenmiş olup tablo 5'de sunulmuştur. İncelenen tüm özellikler (uzunluklar ve kalınlıklar) arasında bir ilişkinin istatistiksel olarak anlamlı varlığı ise Pearson korelasyon testiyle incelenerek Tablo 6'da gösterilmiştir. İstatistiksel anlamlılık düzeyi $P \leq 0,05$ olduğunda kabul edilmiştir (Karagöz, 2015).

Tablo 1. *Bulbus oculi'ye ait morfometrik değerler*

	E1	D1	E2	D2	D3	E3	E4	D4
Kafa Ağırlığı (gr)	1650	1600	1800	1900	1700	1650	1950	2100
Sağ bulbus oculi ağırlığı (gr)	11,4	11,3	11.4	10,4	10,0	11,4	11,0	11,2
Sol bulbus oculi ağırlığı (gr)	10,9	11,3	11,1	11,1	10,2	11,4	11,7	11,5
Sağ bulbus oculi DV çap (mm)	25,9	24,9	24,6	25,8	25,4	25,3	24,6	27,3
Sol bulbus oculi DV çap (mm)	26,1	26,0	23,9	25,0	24,9	24,6	26,4	27,6
Sağ bulbus oculi ML çap (mm)	27,8	28,6	27,6	28,7	27,9	26,9	28,3	28,4
Sol bulbus oculi ML çap (mm)	28,5	24,7	28,4	28,5	26,8	27,4	27,6	28,6
Sağ bulbus oculi axial çap (mm)	26,0	31,3	29,5	26,7	26,5	26,5	28,0	27,1
Sol bulbus oculi axial çap (mm)	29,1	29,9	28,2	26,8	26,5	28,6	29,2	27,7
Sağ cornea DV çap (mm)	12,1	13,1	13,0	14,1	13,7	14,8	13,9	13,2
Sol cornea DV çap (mm)	13,0	13,7	14,1	13,7	12,7	14,4	13,7	13,1
Sağ cornea ML çap (mm)	17,8	18,5	18,3	19,0	18,4	19,4	18,4	18,5
Sol cornea ML çap (mm)	17,1	19,1	19,7	18,6	18,4	19,3	19,4	18,5
Sağ pupilla DV çap (mm)	6,1	6,4	6,1	6,5	7,6	6,5	6,8	6,7
Sol pupilla DV çap (mm)	7,2	7,5	6,5	7,3	7,3	7,2	8,2	6,1
Sağ pupilla ML çap (mm)	11,4	10,7	11,9	11,9	12,8	10,1	11,6	1,6
Sol pupilla ML çap (mm)	11,9	11,4	11,9	11,0	12,8	12,0	12,5	12,0
Sağ lens DV çap (mm)	11,0	11,7	11,2	11,8	11,1	11,7	11,1	11,2
Sol lens DV çap (mm)	10,1	11	11,8	11,6	11,5	11,7	11,6	11,6
Sağ lens ML çap (mm)	11,0	11,5	11,1	12,1	11,7	11,5	11,0	12,0

Tablo 2. *Bulbus oculi'ye ait parametrelerin çok faktörlü ve etkileşimli varyans analizi (Two-Way ANOVA) ile incelenmesi.*

	Bulbus Oculi			
	Ağırlık	**DV**	**ML**	**Axial Çap**
Cinsiyet				
Erkek	11,29±0,09	25,17±0,31	27,81±0,19	28,13±0,45
Dişi	10,83±0,22	25,86±0,37	27,77±0,49	27,81±0,64
Organ				
Sağ	10,95±0,20	25,47±0,31	28,02±0,20	27,70±0,64
Sol	11,17±0,16	25,56±0,41	27,56±0,11	28,25±0,42
Cinsiyet-Organ				
Erkek-Sağ	11,29±0,11	25,10±0,31	27,65±0,29	27,50±0,79
Erkek-Sol	11,30±0,017	25,25±0,59	27,97±0,27	28,77±0,23
Dişi-Sağ	10,62±0,35	25,85±0,51	28,40±0,17	29,90±1,14
Dişi-Sol	11,03±0,28	25,87±0,62	27,15±0,91	27,72±0,76
P değeri				
Cinsiyet	0,225	0,217	0,942	0,692
Organ	0,057	0,871	0,380	0,506
Cinsiyet*Organ	0,051	0,908	0,147	0,384

Veriler, Ortalama ± Standart hata olarak sunulmuştur.

Tablo 3. *Cornea'ya ait ait parametrelerin çok faktörlü ve etkileşimli varyans analizi (Two-Way ANOVA) ile incelenmesi.*

	Cornea			
	Cornea DV	**Cornea ML**	**Pupilla DV**	**Pupilla ML**
Cinsiyet				
Erkek	13,62±0,30	18,67±0,32	6,82±0,24	11,66±0,25
Dişi	13,41±0,15	18,62±0,09	6,92±0,19	11,77±0,26
Organ				
Sağ	13,48±0,29	18,53±0,16	6,58±0,16	11,49±0,28
Sol	13,55±0,20	18,76±0,29	7,16±0,22	11,93±0,19
Cinsiyet-Organ				
Erkek-Sağ	13,45±0,58	18,47±0,33	6,30±0,17	11,24±0,39
Erkek-Sol	13,80±0,30	18,87±0,60	7,27±0,35	12,07±0,14
Dişi-Sağ	13,52±0,23	18,60±0,13	6,80±0,27	11,75±0,43
Dişi-Sol	13,30±0,24	18,65±0,15	7,05±0,32	11,80±0,39
P değeri				
Cinsiyet	0,572	0,897	0,733	0,758
Organ	0,865	0,548	0,068	0,247
Cinsiyet*Organ	0,448	0,640	0,279	0,303

Veriler, Ortalama ± Standart hata olarak sunulmuştur.

Tablo 4. *Lens'e ait parametrelerin çok faktörlü ve etkileşimli varyans analizi (Two-Way ANOVA) ile incelenmesi.*

	Lens		
	DV	**ML**	**Kalınlık Çap**
Cinsiyet			
Erkek	11,27±0,20	11,22±0,24	8,58±0,17
Dişi	11,43±0,10	11,75±0,12	8,48±0,18
Organ			
Sağ	11,35±0,11	11,48±0,15	8,54±0,14
Sol	11,36±0,19	11,48±0,26	8,52±0,21
Cinsiyet-Organ			
Erkek-Sağ	11,25±0,15	11,15±0,11	8,77±0,80
Erkek-Sol	11,290,40	11,30±0,50	8,40±0,34
Dişi-Sağ	11,45±0,17	11,82±0,13	8,31±0,25
Dişi-Sol	11,42±0,14	11,67±0,23	8,65±0,29
P değeri			
Cinsiyet	0,514	0,099	0,699
Organ	0,968	1,000	0,937
Cinsiyet*Organ	0,889	0,618	0,202

Veriler, Ortalama ± Standart hata olarak sunulmuştur.

Tablo 6'da incelenen özelliklere ait korelasyon katsayıları sunulmuştur. Cornea DV çap uzunluğu ile Cornea ML çap uzunluğu arasında pozitif ve istatiksel olarak anlamlı bir ilişki olduğu belirlenmiştir (r= 0,734, p<0,01). Cornea ML çap uzunluğu ile Lens DV çap (r=0,789 , p<0,01), Lens ML çap (r=0,672 , p<0,01) uzunluğu ve Lens kalınlık çapı r=0,535 , p<0,05) arasında pozitif ve anlamlı bir ilişki olduğu tespit edilmiştir. Lens DV çap uzunluğu ile Lens ML çap uzunluğu arasında pozitif ve istatiksel olarak anlamlı bir ilişki gözlenmiştir. (r=0,854 , p<0,01).

Tablo 5. *Kafa ağırlığının Mann-Whitney U analizi ile incelenmesi*

	Kafa Ağırlığı
Cinsiyet	
Erkek	71,80
Dişi	110,86
P değeri	0,772

Tablo 5. *Bulbus oculi'ye ait değerlerin Pearson korelasyon analizleri.*

	Bulbus Oculi Ağırlığı	**Bulbus Oculi Dv Çap**	**Bulbus Oculi Ml Çap**	**Bulbus Oculi Axial Çap**	**Cornea Dv Çap**	**Cornea Ml Çap**	**Pupilla Dv Çap**	**Pupilla Ml Çap**	**Lens Dv Çap**	**Lens Ml Çap**	**Lens Kalınlık Çap**
Kafa Ağırlığı (Gr)	-0,197	0,488	0,435	-0,177	0,103	0,029	0,134	0,339	-0,206	0,355	0,445
Bulbus Oculi Ağırlığı		0,166	-0,139	0,448	0,028	0,189	-0,148	-0,432	0,068	-0,075	0,482
Bulbus Oculi DV Çap			0,051	-0,130	-0,300	-0,244	0,024	0,083	-0,237	0,093	0,052
Bulbus Oculi ML Çap				-0,139	-0,113	-0,279	-0,355	0,032	0,096	0,194	-0,180
Bulbus Oculi Axial Çap					-0,013	0,048	0,091	-0,115	-0,101	-0,297	-0,023
Cornea DV Çap						0,734**	0,232	-0,244	0,448	0,330	0,227
Cornea ML Çap							0,167	-0,108	0,789**	0,672**	0,535*
Pupilla DV Çap								0,422	-0,143	-0,044	-0,257
Pupilla ML Çap									-0,140	0,062	-0,273
Lens DV Çap										0,854**	0,419
Lens ML Çap											0,440

*: P<0,05 **: P<0,01 ***: P<0,001

TARTIŞMA ve SONUÇ

Kıvırcık koyunlarında bulbus oculinin ağırlık ortalamaları erkeklerde sağ 11,29 ± 0,11 gr, sol 11,30±0,01 gr; dişilerde sağ 10,62±0,35 gr, sol 11,03±0,28 gr olarak saptanmıştır. İvesi koyunlarında (Demircioğlu ve Yılmaz, 2019) bulbus oculi ağırlıkları; erkeklerde sağ 11,92±0,37 gr, sol 12,39 ± 0,37 gr, dişilerde sağ 15,69 ± 0,47 gr, sol 15,57 ± 0,48 gr olarak belirlenirken develerde (*Camelus dromedarius*) (Abuagla ve ark, 2016) sağ; 21.30 ± 3.11 gr, sol; 21.10 ± 2.75 gr, Shal, Red Sokoto, West African Dwarf keçilerinde yapılan çalışmada (Olopade ve ark., 2005) sırasıyla; 7.02 ± 0.98 gr, 5.27 ± 0.15 gr, 7.91 ± 1.08 gr, olarak bildirilmiştir.

Olopade ve ark. (2005) bulbus oculinin sahel keçilerinde sağ ML çapı erkeklerde 8.12 ± 0.53 mm, dişilerde 8.34 ± 0.36; sol ML çapı erkeklerde 8.14 ± 0.34 mm, dişilerde 8.20 ± 0.44 mm olarak rapor etmişlerdir.

Yılmaz ve Demircioğlu (2019) İvesi koyunlarında bulbus oculi'nin DV çapını erkeklerde sağ; 25.95 ± 0.49 mm, sol; 26.56 ± 0.53 mm; dişilerde sağ 29.33 ± 0.44 mm, sol; 28.38 ± 0.46 mm, ML çapı ise erkeklerde sağ; 28.11 ± 0.42 mm, sol; 27.50 ± 0.39 mm, dişilerde sağ; 30.50 ± 0.44 mm, sol; 31.00 ± 0.43 mm, olarak belirlerken bu çalışmada kıvırcık koyunlarında erkeklerde sağ DV çap 25,10±0,31 mm, sol 25,25±0,59 mm, dişilerde sağ DV çap 25,85±0,51 mm, sol 25,87±0,62 mm , ML çapı ise erkeklerde sağ; 27,65±0,29 mm, sol; 27,97±0,27 mm, dişilerde sağ; 28.40 ± 0.17 mm, sol; 27.15 ± 0.91 mm olarak bulunmuştur. Bu sonuçlara göre kıvırcık koyunlarının bulbus oculi'sinin ivesi koyunlarına göre erkeklerde DV ve ML çapları birbirlerine yakınken, dişilerde daha düşük, sahel keçilerindekinden ise her iki çapından da daha büyük olduğu tespit edilmiştir.

Kıvırcık koyunlarında cornea'nın ML çapı erkeklerde sağ 18,47±0,33 mm, sol 18,87±0,60 mm, dişilerde sağ 18,60±0,13 mm, sol 18,65±0,15 mm olarak tespit edilmiştir. Fornazari ve ark. (2016) berberi koyununda (*Ammotragus lervia*) corneanın ML çapını 25.05 ± 2.18 mm, DV çapını 17.95 ± 1.68 mm olarak saptarken İvesi koyununda (Demircioğlu ve Yılmaz, 2019) cornea'nın ML çapını erkeklerde sağ 21.99 ± 0.30 mm, sol 21.98 ± 0.32 mm, dişilerde sağ 24.09 ± 0.38 mm, 24.09 ± 0.40 mm olarak bildirmiştir. Çalışmada cornea'nın DV çapı erkeklerde sağ 13,45±0,58 mm, sol 13,80±0,30 mm, dişilerde sağ 13,52±0,23 mm, sol 13,30±0,24 mm belirlenmiştir. İvesi koyunlarında (Demircioğlu ve Yılmaz, 2019) erkeklerde sağ 17.08 ± 0.26 mm, sol 16.87 ± 0.38 mm, dişilerde 17.88 ± 0.43 mm, sol 18.66 ± 0.40 mm olarak bildirmiştir.

Demircioğlu ve Yılmaz (2019), İvesi koyunlarında lens kalınlığını erkeklerde sağ 8.87 ± 0.21 mm, sol 19.28 ± 0.16 mm, dişilerde sağ 10.08 ± 0.14 mm, sol 10.36 ± 0.16 mm olarak, Fornazari ve ark. (2016) berberi koyununda (*Ammotragus lervia*) lens kalınlığını 9.4 ± 0.33 mm olarak bildirmiştir. Okşar (2017) akkaraman koyunlarında lensin kalınlığının erkekte sağ 7.93, sol 7.82, dişide sağ 7.97, sol 8.12 mm olarak tespit etmiştir. Yapılan bu çalışmada lens kalınlığı erkeklerde 8,58±0,17 mm, dişilerde 8,48±0,18 mm olarak saptanmıştır. İvesi koyunlarında Lens kalınlığının erkek ve dişiler arasındaki farkın istatistiksel olarak önemli olduğu bildirilirken, bu çalışmada kıvırcık koyunlarında herhangi bir fark bulunamamıştır.

Kıvırcık koyunlarında pupilla'nın DV çapı erkeklerde sağ 6,30±0,17 mm, sol 7,27±0,35 mm, dişilerde sağ 6,80±0,27 mm, sol 7,05±0,32 mm olarak bildirilmiştir. Pupilla ML çapı erkeklerde sağ 11,24±0,39 mm, sol 12,07±0,14 mm, dişilerde sağ 11,75±0,43 mm, sol 11,80±0,39 mm olarak saptanmıştır. Demircioğlu ve Yılmaz (2019) İvesi koyunlarında pupillanın DV çapını erkeklerde sağ 6.75 ± 0.28 mm, sol 7.38 ± 0.33 mm; dişilerde sağ 7.49 ± 0.28 mm, sol 7.69 ± 0.24 mm olarak. Pupilla'nın ML çapını erkeklerde sağ 11.88 ± 0.29 mm, sol 11.83 ± 0.35 mm, dişilerde sağ 13.58 ± 0.24 mm, sol 13.71 ± 0.24 mm olarak belirlemiştir. Abuagla ve ark. (2016) develerde pupilla'nın çapını sağ 2.04 ± 0.21 cm, sol 2.08 ± 0.23 cm olarak bildirmiştir.

Sonuç olarak, çalışmada yapılan analizler sonucu istatiksel olarak organların cinsiyet ile ilgili olarak sağ ve sol olmasının birbirini etkilemediği sonucuna varılmıştır. Korelasyon analizinde ise anlamlı ve önemli ilişki olduğu görülmüştür.

ÇIKAR ÇATIŞMASI

Yazarlar herhangi bir çıkar çatışması bildirmemiştir.

YAZAR KATKISI

Tüm yazarlar eşit katkı sağlamıştır.

ETİK BEYAN

"**Kıvırcık Koyunlarında Bulbus Oculi'nin Morfometrik ve Makroanatomik Olarak İncelenmesi**" başlıklı çalışmanın yazım sürecinde bilimsel kurallara, etik ve alıntı kurallarına uyulmuş; toplanan veriler üzerinde herhangi bir tahrifat yapılmamış ve bu çalışma herhangi başka bir akademik yayın ortamına değerlendirme için gönderilmemiştir. Hayvan Deneyleri Etik kurullarının çalışma usul ve esaslarına dair yönetmeliğin (15.02.2014) 8. maddesinin (k) bendi 1. fıkrasında belirtildiği üzere çalışmamızda kullandığımız materyal; özel bir çiftliğin kesimhanesinde kesimi yapılan ve karkaslarının insan tüketimine sunulduğu materyal olmasından dolayı HADYEK iznine tabi değildir.

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Research Article

A Molecular and Histopathological Study on Bronchopneumonia in Cats

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ABSTRACT

In this study, it was aimed to determine *Bordetella bronchiseptica, Mycoplasma felis, Staphylococcus aureus and Chlamydia felis*, which cause bronchopneumonia in cats, by Real-time PCR and to compare the pathological findings of the identified agents. The material of the study was constituted of paraffin blocks belonging to the lungs, of which 21 bronchopneumonia were detected in microscopic examination (with Hematoxylin Eosin (HE)) from a total of 78 cats samples brought to Selcuk University, Faculty of Veterinary Medicine, Department of Pathology for pathological diagnosis. Histopathologically, polymorphonuclear leukocytes (PMNL) and mononuclear cell infiltration (MCI) in the bronchi and bronchiolar lumens, desquamation in the bronchi and bronchiolar epithelium, PMNL infiltration with oedama in alveolar lumens and desquamated alveolar epithelium, PMNL infiltration in the interstitium, and peribronchi and peribronchiolar MCI, and pleuritis were detected. Real-time PCR analysis revealed *Bordetella bronchiseptica* in 3 (14.29%) cases, *Mycoplasma felis* in 3 (14.29%), *Staphylococcus aureus* in 5 (23.8%), and *Chlamydia felis* in 5 (23.8%). Morever, *Mycoplasma felis* and *Staphylococcus aureus* infection was detected in 1 case, and *Staphylococcus aureus* and *Chlamydia felis* mixed infection was observed in 1 case. Our results show that relevant agents can frequently be isolated in cases of feline bronchopneumonia.

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INTRODUCTION

Pneumonia in domestic animals may occur due to exposure to foreign substances fungi, viruses, parasites, irritating gases and, especially bacteria (Maxie, 2015; Çiftçi et al., 2021). Cases of bacterial pneumonia usually occur due to some viral infections, drugs that cause immunosuppression or neutropenia, uremia, hyperadrenocorticism, diabetes, diseases that impair immune responses or neutrophil function, including systemic mycoses or primary immunodeficiencies, ciliary dyskinesia and stress (Dear, 2014; Chauhan et al., 2024). Many bacterial agents play a role in the aetiology of bacterial pneumonia in cats, including species such as *Bordetella*, *Mycoplasma, Pasteurella, Francisella, Chlamydia, Mycobacterium*, and *Staphyloccocus* (Padrid et al., 1991; Dye et al., 1996; Chauhan et al., 2024).

Bordetella spp. are gram-negative, aerobic, encapsulated and small coccobacillus-shaped bacteria (Cornelissen et al., 2012). *Bordetella bronchiseptica* causes respiratory diseases in cats, rats, horses, pigs, marine mammals, humans, and especially dogs. Tracheobronchitis and pneumonia in cats have been associated with *B. bronchiseptica*. The disease progresses mildly unless complicated by agents such as *calicivirus* and *feline herpesvirus*, but it can cause fatal bronchopneumonia in kittens (Songer and Post, 2004; Walter et al., 2020).

Most *Mycoplasma* species are commensal organisms that colonise the respiratory tract mucosa. *Mycoplasma spp*. have a species-specific host organism relationship. They are facultative anaerobic microorganisms except *M. pneumoniae*. *Mycoplasma* microorganisms are the smallest prokaryotic cells lacking cell wall and able to multiply on their own (Cornelissen et al., 2012; Eissa, 2024). It has not been fully determined whether *Mycoplasma* is a primary pathogen or an opportunistic pathogen in cats and dogs. However, *M. cynos* is known to cause fibrinous pneumonia in dogs and *M. felis* cause fibrinous pneumonia in cats. Macroscopically, hepatised areas are identified in the lung. *M. felis* causes mostly pneumonia and conjunctivitis in young cats (Songer and Post, 2004; Çiftçi et al., 2021; Chauhan et al., 2024).

Staphylococci are gram-positive, cocci-shaped, nonmotile, sporeless, facultative anaerobic, catalase-positive bacteria that occur in chains, singly, and often in the appearance of a bunch of grapes (Songer and Post, 2004; Rasheed and Hussein, 2021). The presence of *Staphylococcus* in the natural flora of pet mucosa paves the way for *Staphylococcus* infections. Most infections occur as a result of damage to the integrity of the skin or mucous membranes due to various reasons. *S. aureus* is the causative agent of necrotic pneumonia. *S. aureus* causes suppurative infections and septicemia in all species (Songer and Post, 2004; Cornelissen et al., 2012).

Chlamydiae are gram-negative, obligate intracellular bacteria. Although small and oval-shaped, their shapes may vary during reproduction stages. *Chlamydia* is spread by direct contact or aerosol (Songer and Post, 2004; Cornelissen et al., 2012). *Chlamydia felis* is endemic among domestic cats worldwide and causes conjunctivitis, rhinitis and pneumonia (Songer and Post, 2004; Sykes, 2021). They cause serous, catarrhal, and sometimes purulent inflammation in the upper respiratory tract and, the most important lesion, interstitial pneumonia (Songer and Post, 2004; Çiftçi et al., 2021).

In this study, it was aimed to determine the presence of *Bordetella bronchiseptica, Mycoplasma felis, Staphylococcus aureus* and *Chlamydia felis*, which cause bronchopneumonia in cats, by Real-time PCR and to compare the pathological findings of the identified agents.

MATERIAL AND METHODS

Animal materials

The material of the study was paraffin blocks belonging to the lungs of which 21 bronchopneumonia were detected in microscopic examination (with Hematoxylin and Eosin (H&E)) from a total of 78 cat samples brought between 2022-2023 years for pathological diagnosis to Selcuk University Faculty of Veterinary Medicine, Department of Pathology. The sections were examined under a light microscope (Olympus BX51, Tokyo, Japan) and photographed. The age groups of the cats that comprised the study material were grouped according to Vogt et al.

(2010). Cases with histopathological findings of viral, parasitic and fungal agents, trauma and gunshot wounds, and primary tumour focus or metastasis were not evaluated as study materials.

Real-time PCR analysis

Sections from paraffin blocks of bronchopneumonia were taken into sterile eppendorf tubes. DNA isolation was performed using the commercial isolation kit (QIAamp® DNA FFPE Tissue Kit, Cat. No: 56404) following the instructions of the manufacturer. The isolated DNAs were stored at -20°C for use in Real-time PCR analyses. DNA copies of *Bordetella bronchiseptica*, *Mycoplasma felis*, *Staphylococcus aureus* and *Chlamydia felis* were investigated using the QIAGEN Rotor-Gene Q Real-time PCR device, using primers prepared by a private company in accordance with the instructions of the manufacturer. Deionised water was used as the negative control. The primer sequences used in Real-time PCR analysis are given in Table 1.

Table 1. *Primer sequences used in the study.*

Agents	Primer sequences
Mycoplasma felis	F: 5′-AGAAGCACTTGCGGGAGATA-3′
	R: 5′-CAACGATACGAGGAACACCA-3′
Staphylococcus aureus	F: 5′-GAT GAC CAA TAT TCT GGA TGG-3′
	R: 5′-TTA GAA CAG CAT CTC AAT GTG-3′
Bordetella bronchiseptica	F: 5′-CCCCCGCACATTTCCGAACTTC-3′
	R: 5′-AGGCTCCCAAGAGAGAAAGGCTT-3′
Chlamydia felis	F: 5′-GGCTGAAAGATGAGCTCGAGAG -3′
	R: 5′-TCTCAAAGCACAGCGGACTG-3′

F: Forward, R: Reverse

RESULTS

Of the cats with microscopically detected bronchopneumonia, 9 were female and 12 were male. Seven of these cases were under six months old (kitten), eight were between seven months and two years old (junior), two were between three and six years old (prime), three were between six and ten years old (mature), and one of them was 12 years old (senior). It was determined that 10 of the lung samples examined in the study belonged to cats staying in a shelter, 8 to stray cats brought by municipal authorities or animal lovers, and 3 to owned cats. The agents amplified by Real-time PCR from the lungs with microscopically detected bronchopneumonia and the distribution of these according to age and gender are given in Table 2.

Table 2. *Distribution of Bordetella bronchiseptica, Mycoplasma felis, Staphylococcus aureus and Chlamydia felis in lung tissues with bronchopneumonia by Real-time PCR according to age and gender.*

Real-time PCR result	N (21)	Male	Female	Kitten	Junior	Prime	Mature	Senior
Bordetella bronchiseptica	3	1	2	2			1	
Mycoplasma felis	2	1	1		2			
Staphylococcus aureus	5	4	1	1	2		1	1
Chlamydia felis	4	2	2	1	2	1		
Mycoplasma felis* + *Staphylococcus aureus	1	1		1				
Staphylococcus aureus* + *Chlamydia felis	1	1		1				
Samples where the agent could not be determined by Real-time PCR	5	2	3	1	2	1	1	

Macroscopic and microscopic results

Macroscopic findings of the lungs examined in the study are presented in Table 3. PMNL infiltration in the bronchi, bronchiole lumens and interstitium of the lung was observed microscopically in 3 of the lungs where *Bordetella bronchiseptica* was detected; while in 3 of them, alveolar, bronchi and bronchiolar epithelial desquamation was observed, MCI around the bronchi and bronchioles in 2 cases. Oedama in the alveoli and multifocal areas of necrosis scattered throughout the lung parenchyma were noted in 2 of these lungs, and pleuritis was noted in 1 of them (Figure 1-A).

Microscopically, PMNL infiltration in the bronchi and bronchiole lumens was observed in 1 of the lungs where *Chlamydia felis* was detected, MCI around the bronchi and bronchiole and in the lung interstitium in 2 cats, desquamation in the bronchi and bronchiolar epitheliums in 4 cats, and alveolar epithelial desquamation and oedama in 2 cats. Additionally, findings of interstitial pneumonia were detected in 1 case (Figure 1-B-D).

Microscopically, PMNL infiltration in the bronchi, bronchioles and alveolar lumens was observed in 2 of the lungs where *Mycoplasma felis* was detected, and bronchiectasis and desquamation of the bronchi and bronchiole epithelium were observed in 3 of them. MCI located around the bronchi and bronchioles were noted in 3 of these lungs. Pleuritis was detected in 3 of the lungs (Figure 1-C).

In the lungs where *Staphylococcus aureus* was detected, microscopically, it was determined that in 5 of them, the bronchi, bronchiole and alveoli lumens were filled with exudate, mostly consisting of neutrophil leukocytes, and there was desquamation in the bronchi, bronchiole and alveoli epithelium. PMNL infiltrates showing abscess formation scattered throughout the interstitium were noted in 5 cats, and pleuritis in 2 cats (Figure 1-C).

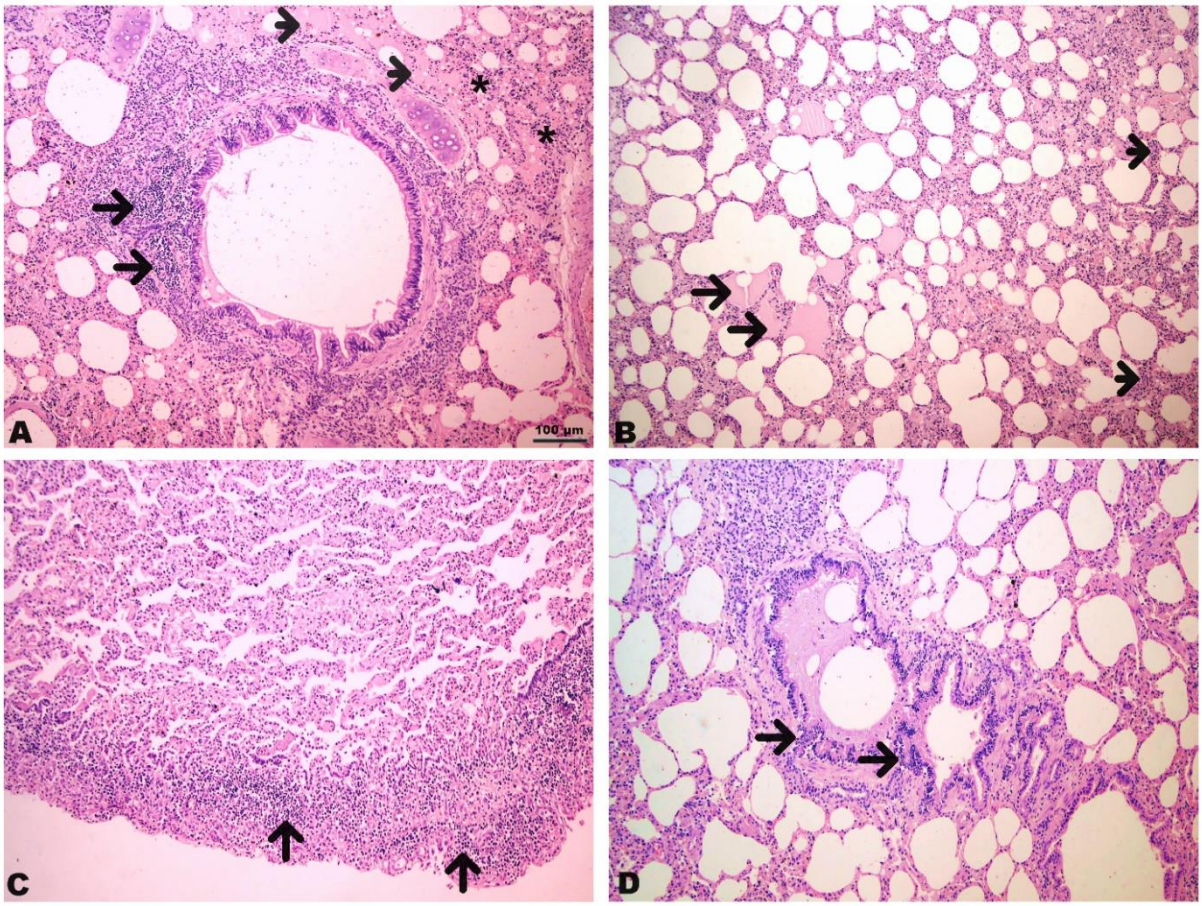

Figure 1. *Microscopic view of bronchopneumonia lung tissues, Hematoxylin&Eosin, x200.* ***A.*** *MCI around the bronchi (arrows), PMNL infiltration in the interstitium (stars) and alveolar oedama (arrowheads) in a case with Bordetella bronchiseptica.* ***B.*** *Alveolar oedama (arrows) and MCI (arrowheads) in the interalveolar septum in a case in which Chlamydia felis was detected.* ***C.*** *Microscopic appearance of pleuritis (arrows) in a case in which Mycoplasma felis and Staphylococcus aureus were detected.* ***D.*** *Peribronchiolar MCI (arrows) in the sample with Chlamydia felis.*

Table 3. *Macroscopic findings of lungs with bronchopneumonia*.

MACROSCOPIC FINDINGS	Real-time PCR result			
	Bordetella bronchiseptica	***Mycoplasma felis***	***Staphylococcus aureus***	***Chlamydia felis***
	(N=3)	**(N=3)**	**(N=5)**	**(N=5)**
Red, viscous areas in the lungs	**3**	**3**	**2**	**1**
The cross-sectional surface of the lung is swollen and wet.	**3**	**3**	**2**	**1**
Foamy content in trachea and bronchi	**3**	**1**	**4**	**4**
Fluid in the chest cavity	**-**	**2**	**1**	**-**

Real-time PCR results

Although bronchopneumonia was detected microscopically in the analyses performed with Real-time PCR, amplification could not be obtained with the primers used in five lung tissues. In cats where amplification was determined with primer sequences belonging to more than one agent in Real-time PCR analyses, the agent with the lowest "Cycle Threshold (CT)" value was accepted as the causative of bronchopneumonia. The detection status of DNA copies of *Bordetella bronchiseptica*, *Mycoplasma felis*, *Staphylococcus aureus* and *Chlamydia felis* by Real-time PCR from paraffin blocks of lungs with bronchopneumonia and their CT values are given in Table 4.

Table 4. *Determination status and CT values of Bordetella bronchiseptica, Mycoplasma felis, Staphylococcus aureus and Chlamydia felis DNA copies by Real-time PCR.*

NO	CT VALUES DETERMINED BY REAL TIME PCR			
	Bordetella bronchiseptica	***Mycoplasma felis***	***Staphylococcus aureus***	***Chlamydia felis***
1			28	
2*				
3	22			
4			24	
5				28
6	28			
7*				
8			28	
9			28	
10		30		
11				30
12		28		
13				24
14*				
15		24	27	
16*				
17				28
18*				
19			28	24
20			22	
21	28			
TP	3	2+1**	5	4+1**

* Samples where amplification could not be determined with the primers used in the study, ** In polymicrobial cases, the agent with a lower CT value was considered as the agent causing bronchopneumonia.

DISCUSSION

Determining the aetiology of respiratory system diseases in cats is one of the important problems encountered in veterinary clinics (Dear, 2020; Slaviero et al., 2021; Tural and Tuzcu, 2023). In this study, agents such as *Bordetella bronchiseptica, Mycoplasma felis, Staphylococcus aureus* and *Chlamydia felis* from paraffin blocks of cat lungs with bronchopneumonia were determined by Real-time PCR and their pathological findings were compared.

Identification of the causative agent is necessary to determine the aetiology of bacterial pneumonia in cats. However, usually, the success of identification decreases due to factors such as taking samples for bacteriological examinations, contamination during transport to the laboratory, and empirical antibiotic use (Garcia et al., 2015; Murray, 2015; Bonnet et al., 2020). In these cases, methods based on amplification of the genomic DNA of the agent appear to be an important option in determining the appropriate treatment. Real-time PCR has become an important diagnostic method in the field of veterinary medicine in recent years due to its rapid results, ability to detect microorganisms such as *Mycoplasma* and *Chlamydia* that are difficult to detect with conventional methods, and its high sensitivity (Hyeran et al., 2006; Pantchev et al., 2010; Sibitz et al., 2011; Tuzcu et al., 2021; Tuzcu et al., 2022; Akçakavak et al., 2023; Tuzcu et al., 2023).

There are reports that outline that bronchopneumonia in cats can occur at any age and that there is no preference of breed or gender (Tural and Tuzcu, 2023). Slaviero et al. (2021) in their study evaluating 1749 cat necropsies found that the cause of death was pneumonia in 78 of the cats. Of these cats, 14 were kittens (17.9%), 19 juniors (24.4%), 13 primes (16.7%), 14 matures (17.9%), 8 seniors (10.3%) and 5 geriatric (6.4%). They also reported the absence of age information in five cases (6.4%). In the current study, 7 of the cats with bronchopneumonia were younger than 6 months old (kitten) (33.3%), 8 were between 7 and 24 months old (junior) (38.09%), 2 were between 3 and 6 years old (prime) (9.52%), 3 were determined to be samples of cats between the ages of 6 and 10 (mature) (14.28%), and 1 of them was determined to be from a 12-year-old cat (senior) (21%). These results are compatible with the literature.

In retrospective studies aimed at determining the cause of death in cats, the mortality rate due to pneumonia has been reported to be between 1% and 6.5% (Egenvall et al., 2009; Togni et al., 2018; Slaviero et al., 2021). In this study, bronchopneumonia was detected in 21 of 78 cats necropsied. The determined bronchopneumonia rate is high compared to the literature. This may be related to the fact that the majority (18/21) of the cats included in the study were stray and shelter cats. Additionally, this study found that the rate of bronchopneumonia in male cats (12/9) was higher than in females. This is consistent with the findings of Foster et al. (2004) study, in which they reported that the prevalence of pneumonia in male cats was 2.4 times higher than in females.

In the current study, macroscopic findings recorded in cats with microscopically diagnosed bronchopneumonia were as follows: red, sunken, viscous areas in the lungs, the cross-sectional surface of the lungs appearing flooded and moist, a foamy content in the trachea and bronchi, and the presence of fluid in the chest cavity. These macroscopic findings were signs of bronchopneumonia, not specific to the agent.

Lappin et al. (2017), in their study on respiratory system diseases of cats, reported that the bacterial agents determined by PCR were *Mycoplasma* species (62.5%), *Bordetella* species (47.5%), *Staphylococcus* species (12.5%) and *Streptococcus* species (10%). Dear (2020), in a study examining pneumonia seen in cats and dogs, reported, based on literature data (Foster et al., 2004; Radhakrishnan et al., 2007; Proulx et al., 2014), that 22-71% of pneumonia in cats was caused by *Bordetella bronchiseptica*, 2-25% by *Klebsiella pneumoniae*, 30-70% by *Mycoplasma spp*. and 6-21% by *Streptococcus spp*. In this study, the data obtained by Real-time PCR are 3/21 (14.29%) for *Bordetella bronchiseptica*, 5/21 (23.8%) for *Staphylococcus aureus*, 3/21 (14.29%) for *Mycoplasma felis*, and 5/21 (23.8%) for *Chlamydia felis*. It has been determined that the rates found are compatible with literature data. In addition, in this study, polymicrobial infections were detected in 2 (9.5%) of the adult cats with respiratory tract infections, as reported in previous (Dear, 2014).

In this study, *Staphylococcus aureus* genomic DNA was detected by Real-time PCR in 7 of the cats examined. Researchers have reported that *Staphylococcus spp*. causes lung abscess, suppurative bronchopneumonia and pyothorax (Maxie, 2015; Reinero and Lee-Fowler, 2021; Sim et al., 2021). It has been reported that microscopically, neutrophil leukocyte infiltrations and desquamated epithelial cells in the alveoli, bronchi and bronchiolar lumens, as well as hyperemia and oedama, in cats with *Staphylococcus* spp. detected. It has also been reported that small abscesses are formed in the lung, most of which are surrounded by a fibrous capsule (Çiftçi et al., 2021; Sim et al., 2021; Slaviero et al., 2021; Chauhan et al., 2024). In this study, the fact that suppurative

pneumonia was detected in 5 of the cats in which *Staphylococcus aureus* was detected by Real-time PCR is consistent with the literature.

Present study, genomic DNA belonging to *Bordetella bronchiseptica* was amplified in 3 of the lung samples examined by Real-Time PCR. In this study, bacteria could not be detected microscopically in cilia. The fact that genomic DNAs belonging to *Bordetella bronchiseptica* were amplified by Real-Time PCR in these cases reveals that the diagnosis should be confirmed by PCR.

There are studies associating tracheobronchitis and pneumonia with *B. bronchiseptica* in cats (Bemis, 1992; Binns et al., 1999; Foster et al., 2004). *B. bronchiseptica* can cause fatal bronchopneumonia in kittens and, microscopically, neutrophils are detected in the bronchi lumen (Songer and Post, 2004; Maxie, 2015; Chauhan et al., 2024). *B. bronchicepta* causes catarrhal tracheitis and bronchitis, as well as catarrhal-purulent bronchopneumonia (Ettinger and Feldman, 2010). In this study, findings such as PMNL infiltration in the bronchus and bronchiolar lumens and interstitium of the lung, desquamation in the bronchi, bronchiolar and alveolar epithelium, and oedama in the alveoli, determined microscopically in the lung tissues where *Bordetella bronchiseptica* was detected, were found to be compatible with the literature.

Although it has not been precisely determined whether *Mycoplasma spp*. are the primary pathogen or an opportunistic pathogen in cats, there are reports that *M. felis* is the causative agent of fibrinous pneumonia in cats (Songer and Post, 2004; Çiftçi et al., 2021; Shil et al., 2022). There are reports that serous exudate, neutrophil leukocyte infiltration and desquamated alveolar epithelium are microscopically detected in the alveolar lumens in *Mycoplasma* pneumonia and that an exudate consisting of abundant neutrophil leukocytes, desquamated epithelium and mucus is found in the bronchi and bronchiolar lumens (Ettinger and Feldman, 2010; Swennes and Fox, 2014; Reinero and Lee-Fowler, 2021; Chauhan et al., 2024). In this study, the microscopic findings determined in the lungs in which *M. felis* was amplified by Real-time PCR were similar.

Chlamydia felis is endemic among domestic cats worldwide and is known to cause conjunctivitis, rhinitis and pneumonia (Browning, 2004; Songer and Post, 2004; Wasissa et al., 2021). It causes serous, catarrhal, and sometimes purulent inflammation in the upper respiratory tract, conjunctivitis, and interstitial pneumonia, which is its most important lesion (Kartashov et al., 2019; Schmal-Filius et al., 2020; Çiftçi et al., 2021; Wasissa et al., 2021). In this study, interstitial pneumonia was detected in 1 of the cases in which *Chlamydia felis* was detected, a finding which was similar to the literature.

CONCLUSION

As a result, in this study, *Bordetella bronchiseptica, Staphylococcus aureus, Mycoplasma felis* and *Chlamydia felis* agents were detected at rates of 14.29%, 23.8%, 14.29% and 23.8%, respectively, by Real-time PCR. Our results show that relevant agents can often be isolated in cases of feline bronchopneumonia, demonstrating the importance of polymicrobial agents in cases of feline bronchopneumonia and indicating that more than one bacterial species should be investigated.

AUTHOR CONTRİBUTİON

All authors contributed equally.

ETHICAL STATEMENT

Scientific rules, ethics and citation rules were followed during the writing process of the study titled "**A molecular and histopathological study on bronchopneumonia in cats**"; There was no tampering with the data collected and this study was not sent to any other academic publication environment for evaluation. The necessary ethics committee permissions were obtained by SUVDAMEK at its meeting dated 29.02.2024 and numbered 2024/35.

CONFLICT OF INTEREST

The authors declared no conflict of interest.

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Research Article

Seroprevalence of Maedi-Visna Infection in Sheep in the Central Black Sea Region of Türkiye

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ABSTRACT

Maedi-Visna is a slowly progressive infection of sheep that affects the respiratory and nervous systems and causes significant yield losses worldwide. This study was conducted to assess the seroprevalence of Maedi-Visna infection in sheep across several provinces in the Central Black Sea region of Türkiye, namely Samsun, Sinop, Ordu, Giresun, Amasya and Tokat. A total of 476 sheep serum samples were collected for further analysis. The presence of antibodies in the sera was determined by Ab ELISA. As a result of the study, 263 (55.25%) blood serum samples were positive for the presence of MVV antibodies. Seropositivity rates by province were as follows: Samsun 45%, Sinop 80%, Ordu 58.75%, Giresun 35%, Amasya 38.75%, Tokat 75%. Notably, our findings suggest a significantly high seroprevalence of Maedi-Visna infection in this region compared to other studies conducted in different parts of Türkiye This information is pivotal for understanding the extent of the infection in the sheep population of the Central Black Sea region and can contribute to the development of strategies for disease management and control.

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INTRODUCTION

Maedi-Visna (MV) is a lifelong and incurable viral infection with an extended incubation period in sheep. Also referred to as progressive pneumonia of sheep, this disease poses a significant challenge to sheep farming globally (Boer et al., 1979).

MV is a lifelong and incurable viral infection with an extended incubation period in sheep. Also referred to sometimes as progressive pneumonia of sheep and this disease represents a significant challenge to sheep farming globally (Boer et al., 1979). The causative agent is classified within the *Lentivirus* genus of the *Orthoretrovirinae* subfamily, belonging to the *Retroviridae* family (ICTV, 2023). Owing to its genetic similarity with Caprine arthritis encephalitis virus, found in the same family, these two viruses are collectively referred to as lentivirus infections of small ruminates (Blacklaws,2012). According to phylogenetic analysis, small ruminant lentiviruses are categorized into five genotypes. Maedi-Visna virus (MVV) is classified under genotype A (Glaria et al., 2012). The virus primarily targets the immune system by infecting monocytes and macrophages. Due to the generally slow viral replication, the disease exhibits a slowly progressive course, and clinical symptoms are nonspecific in the early stages. The primary mode of transmission is horizontal, occurring through colostrum and aerosol from the infected mother (Dawson,1980). Additionally, there is ongoing evaluation regarding the potential transplacental transmission of the virus, although this mechanism has not been fully elucidated. (Broughton-Neiswanger et al., 2010). The organs predominantly affected by MVV include the lungs, mammary glands, nervous system tissues and joints. The Maedi form of the disease is linked to respiratory symptoms, while the Visna form is associated with central nervous system manifestations (Minguijón et al., 2015; Gomez-Lucia et al., 2018). The maedi form exhibits the most prevalent clinical manifestations of the infection. Initial symptoms include a decline in body condition, with affected animals trailing behind the herd. In the advanced stage, dyspnea is characterized by an elevated respiratory rate and the presence of lymphocytic interstitial pneumonia becomes evident (Christodoulopoulos,2006; Lopez and Martinson,2017). MVV can induce indurative, non-suppurative interstitial mastitis in the mammary gland. The virus replication in macrophages and mammary gland epithelial cells leads to a substantial reduction in milk production (Minguijón et al., 2015). The Visna form of the disease is less common than the maedi form. Clinical signs observed in Visna include weight loss, impaired coordination, weakness in the hind limbs and eventual paralysis (Christodoulopoulos,2006). The diagnosis of infection relies on either directly detecting the presence of the virus or identifying antibodies specific to the agent (Kaba et al., 2013). At present, there is no effective treatment option against MVV infection. Despite numerous vaccine studies, including live attenuated, recombinant, and DNA vaccines, no success has been achieved in preventing the disease (Cheevers et al., 1994; Pétursson et al., 2005; González et al., 2005; Torsteinsdóttir et al., 2007).

The objective of this study was to assess the prevalence of Maedi-Visna infection in sheep across the provinces of Samsun, Sinop, Ordu, Giresun, Amasya, and Tokat in the Central Black Sea Region, aiming to determine the current status of the infection in the region.

MATERIAL AND METHOD

Sampling

Our study utilized 476 sheep serum samples that came from Samsun, Sinop, Ordu, Giresun, Amasya, and Tokat provinces located in the Central Black Sea Region of Türkiye (Figure.1). Blood Samples were collected from various areas in a consistent manner between January 2018 and December 2020 from clinically healthy sheep flocks aged between 1-2 years. General clinical findings were examined to ensure the health status of the animals, and the appropriate number of animals for the study were determined randomly. Serum samples were heat-inactivated at 56° C for 30 minutes and stored at -20 °C until testing by Enzyme-Linked Immuno Sorbent Assay (ELISA) method.

Figure 1. *Map showing the study area where serum samples were collected.*

ELISA Assay

For the detection of MVV specific antibodies, a commercially available indirect ELISA test kit, "ID.vet ID Screen MVV/ CAEV Indirect Screening test (Grabels-France)" was used. After performing the test according to the manufacturer's instructions, the plates were read at 450 nm and OD values were calculated. The specificity of the kit is 99.6% in sheep and 99.2% in goats, while its sensitivity is 98.9% in sheep and 98.6% in goats (Nowicka et al., 2014).

According to the kits manual, samples were evaluated as follows:

S/P%= $\frac{ODsample-ODnc}{ODpc-ODnc} x100$ (S/P%: sample/positive percentage, ODsample: optic density of the sample, ODnc: optic density of negative control, ODpc: optic density of positive control).

- Samples presenting an S/P ratio equal to or below 50% were considered negative.
- Samples presenting an S/P ratio between 50% and 60% were considered doubtful.
- Samples presenting an S/P ratio equal to or above 60% were considered positive.
- The results were considered valid when the OD of the positive control was greater than 0.350, and the mean value of the positive and negative controls was more than 3.

RESULTS

From 476 serum samples that were tested, 263 serum samples were evaluated as positive for MVV antibody. Whereas the overall seropositivity rate was 55.25%, the seropositivity rates per province were as follows: Samsun 36/80 (45%), Sinop 64/80 (80%), Ordu 47/80 (58.75%), Giresun 28/80 (35%), Amasya 31/80 (38.75%), Tokat 57/76 (75%) (Table.1).

Table 1. *Seropositivity distribution by provinces*

Province	Serum sample	Positive serum	Seropositivity(%)
Samsun	80	36	%45
Sinop	80	64	%80
Ordu	80	47	%58.75
Giresun	80	28	%35
Amasya	80	31	%38.75
Tokat	76	57	%75
Total	476	263	%55.25

DISCUSSION

MVV infection represents a persistent lentivirus infection in sheep (Peterhans et al., 2004). Initially perceived as distinct diseases, it was later recognized that Maedi and Visna represent different clinical courses of the same underlying disease (Sigurdsson et al., 1952; Dawson,1980). The disease initially was reported in Iceland in 1939, and various research efforts have been ongoing since the 1940s (Schaller et al., 2000; Straub, 2004; Reina et al., 2009; Zhang et al., 2013). Presently, Maedi-Visna infection is widespread worldwide, with the exception of Australia and New Zealand. Recognizing its substantial economic impact on livestock, the disease is listed among the notifiable terrestrial and aquatic animal diseases by the World Organization for Animal Health (WOAH, 2018).

MVV infection is prevalent in Turkey and worldwide, prompting numerous studies on its seroprevalence in recent years. The first investigation into the virus's presence in Turkey was conducted by Alibaşoğlu et al. (1975), focusing on pathological findings for virus detection. Subsequently, many studies have been undertaken to detect the virus using serological and virological methods (Girgin et al., 1987; Karaoğlu et al., 2003; Çimtay et al., 2004; Arslan et al., 2012; Gürçay et al., 2013).

The virus was first isolated by Tan and Alkan (2002), and molecular characterization was subsequently conducted by Muz et al. (2013). Numerous epidemiological studies have been conducted in between them and after, revealing diverse seropositivity rates in different regions of Turkey. A study conducted on 198 sheep sera from Erzurum province, 1.5% seropositivity was detected (Schreuder et al., 1988). Burgu et al. (1990), found a higher seropositivity rate of 23.9% among 1099 blood serum samples collected from sheep farms across all of Turkey. Similarly, study conducted on 465 sheep serum samples in Van province, reported just a 6.45% seropositivity rate (Akkan et al., 2009). In Istanbul province, a study conducted with 542 serum samples revealed a seroprevalence rate of 15.3% (Prezıuso et al., 2010), while Azkur et al. (2011) reported a seroprevalence of 19.4% in Kırıkkale. Yavru et al. (2012) detected a seropositivity rate of 2.90% in 1343 serum samples from enterprises in the Konya province. Albayrak et al. (2012) conducted a study in the Black Sea region, revealing a serosensitivity rate of 23.5% in 583 serum samples. Another similar study conducted in Afyonkarahisar reported a lower seroprevalence of around 5.7% (17/294) (Arık et al., 2015). Ün et al. (2018) determined a seroprevalence of 5.29% among 1096 sheep sera from different farms in Şanlıurfa province. Finally, in a study conducted most recently in Kars province in 2021, a 16% (32/200) seropositivity rate was revealed (Gezer et al., 2021).

This study investigated the seroepidemiology of MVV infection across six provinces in the Central Black Sea Region: Samsun, Sinop, Ordu, Giresun, Amasya, and Tokat. Our study showed 55.25% overall seroprevalence for MMV infection in this region, with Sinop exhibiting the highest seroprevalence at 80% and Giresun the lowest at 35%. Our findings indicate a notably higher seroprevalence of MVV infection in the Black Sea Region compared to previous studies conducted in Turkey. Moreover, this rate emphasizes a significant increase compared to the previous study by Albayrak et al. (2012) within the same region. This increase could be attributed to changes in animal populations over time and the introduction of new animals into the herds, especially from abroad.

MVV infection follows a persistent course and lacks an effective treatment, posing significant challenges for disease control. The virus establishes a permanent infection by integrating into the host genome, akin to other lentiviruses, and can mutate to evade neutralizing antibodies, making the efforts to control the disease more complicated. With no effective vaccine currently available, the emphasis lies on implementing robust control programmes to prevent the spread of the disease. In this context, we advocate for prioritizing prevention strategies to thwart disease introduction into herds. This necessitates sourcing animals from MVV-free herds as a primary measure to mitigate disease transmission.

Early diagnosis plays a pivotal role in controlling persistent infections, underscoring the importance of regular screening tests in large-scale enterprises and small family-run operations. So, prior to introducing new animals into the herd, rigorous testing for infection and subsequent quarantine until test results are obtained are imperative measures. Upon detection of infection, fast identification and elimination of the source should be the primary objective. In this regard, it is recommended to identify and segregate seropositive animals from the herd, and separate offspring born from infected mothers, raising them alone with the possibility of providing heat-treated colostrum feeding, because it is considered as the most

important transmission route of infection (Blacklaws et al., 2004). Moreover, selecting a breeding system appropriate for herd size is crucial, particularly in densely populated herds; also, for the control of horizontal transmission, semi-intensive or extensive feeding according to herd density instead of intensive feeding is an essential control measurement.

Based on the evidence that MVV can be transmitted via infected ram semen (Preziuso et al.,2003; Kalogianni et al.,2020), careful selection of breeding rams from infection-free herds is paramount to prevent transmission. Recent studies have shed light on resistant and susceptible genes associated with small ruminant lentiviruses, suggesting the possibility of the presence of some genes that may be resistant to this disease (Yaman et al., 2019; Riggio et al.,2023; Heaton et al.,2013; White and Knowles,2013). By leveraging the findings of these studies that highlighted the potential for genetic resistance against the disease, it may be feasible to to breed genetically resistant breeds, offering enhanced protection against MVV infection.

CONCLUSIONS

In conclusion, our study revealed the current status of MVV infection, which causes significant yield losses in small ruminants in the Black Sea Region. The data we obtained showed that the seroprevalence of the infection has increased and effective control methods should be taken to prevent the disease.

AUTHOR CONTRIBUTION

All authors contributed equally.

ETHICAL STATEMENT

Scientific rules, ethics and citation rules were followed during the writing process of the study titled " **Seroprevalence of Maedi-Visna Infection in Sheep in the Central Black Sea Region of Türkiye**"; There was no tampering with the data collected and this study was not sent to any other academic publication environment for evaluation. No ethical approval was required, as no animals were culled or treated during this study. Therefore, the study was not subject to ethics committee permission according to Article 2 (2) b, "Non-experimental clinical veterinary practices," of the Regulation on Working Procedures and Principles of Animal Experiments Ethics Committees by the Republic of Turkey Ministry of Agriculture and Forestry.

CONFLICT OF INTEREST

The authors declared no conflict of interest.

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Research Article

The Antimicrobial Effects of Kyrgyz Honey

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ABSTRACT

Honey is a sweet and versatile substance produced by the complex interactions between bees and flowers. Honey is not only a nutrient, but also a bee product with antibacterial properties. Kyrgyzstan's geographical location, including the Tien Shan and Altai mountains, has made it one of the most important beekeeping regions in Central Asia. The rich flora and natural environment of these regions give Kyrgyz honey unique properties. The aim of this study is the determination of the antibacterial activity of honey samples on sale in the Chuy region of Kyrgyzstan. In this context, the antimicrobial effects of different honeys against *Staphylococcus aureus* and *Escherichia coli* were investigated using the agar-well diffusion and disc diffusion methods, with the aim of comparing the effectiveness of these methods. This study, conducted on white honey, buckwheat honey and three different multifloral honeys, provides important information for understanding the microbial effects of honey. Although the zones formed were more clearly visible when analysed using the agar-well diffusion method, it was found to be more sensitive than the disc diffusion method. As a result, it has been observed that different types of honey have different antimicrobial effects.

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Kırgız Balının Antimikrobiyal Etkileri

ÖZET

Bal, arılar ve çiçekler arasındaki kompleks etkileşimler sonucunda üretilen tatlı ve çok yönlü bir maddedir. Bal sadece bir besin maddesi değil, aynı zamanda antibakteriyel özelliklere sahip bir arı ürünüdür. Kırgızistan'ın coğrafi konumu, Tien Shan ve Altay Dağları'nı içermesi nedeniyle, Orta Asya'nın önemli arıcılık bölgelerinden biri olmasını sağlamıştır. Bu bölgelerin zengin florası ve doğal ortamı, Kırgızistan balının benzersiz özellikler kazanmasına yardımcı olmaktadır. Bu çalışmanın amacı, Kırgızistan'ın Chuy bölgesinde satılan bal örneklerinin antibakteriyel aktivitesini belirlemektir. Bu kapsamda *Staphylococcus aureus* ve *Escherichia coli*'ye karşı çeşitli balların antimikrobiyal etkileri agar-well difüzyon ve disk düfizyon yöntemleri kullanılarak araştırılmış ve bu yöntemlerin etkinliğinin karşılaştırılması amaçlanmıştır. Beyaz bal, Karabuğday balı ve üç farklı multifloral bal kullanılarak gerçekleştirilen bu çalışma, balın mikrobiyal etkilerini anlamak adına önemli bilgiler sunmaktadır. Agar-well difüzyon yöntemi kullanılarak yapılan analizlerde oluşan zonlar daha net görünürken, bu yöntem disk difüzyon yöntemine göre daha duyarlı olduğu belirlenmiştir. Sonuç olarak, farklı tür ballarda farklı antimikrobiyal etkilere sahip olduğu gözlemlenmiştir.

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INTRODUCTION

Honey, a sweet and viscous substance, is mainly produced by honeybees (Apis mellifera) (Hossain et al., 2022). Honey is a food product known and appreciated throughout the world. Flower origin, colour, aroma and taste are important factors in determining the quality of honey (Piana et al.,2023). In addition to being an important animal product, honey has become an important antimicrobial food because it has antibacterial properties and does not cause microbial resistance (Acaroz et al.,2024; Asma et al.,2022; İplikçioğlu-Çil et al., 2020). There is great interest in destroying foodborne pathogens or preventing their multiplication in food (Çakmak et al.,2023; İplikçioğlu-Çil et al.,2020; Schell et al.,2022). It strongly suggests that the antimicrobial components of honey have the potential to inhibit the proliferation and spread of pathogenic micro-organisms (İstanbullugil et al.,2023). There have been many studies of the antibacterial effects of honey on bacteria associated with wound healing (Balazs et al.,2023; Israili,2014; Skadins et al., 2023; Yupanqui Mieles et al.,2022). Recently there has been a growing demand for monofloral honeys with unique properties (Tananaki et al.,2021). Most of the honeys produced in Kyrgyzstan are polyfloral honeys, and it is difficult to produce monofloral honeys. For this reason, Kyrgyz honeys are often named after the places where they are produced; they are distinguished by the names of mountainous regions, for example, Toktogul, Sary-Chelek, Kara-Soro, At-Bashy (Mazhitova and Smanalieva,2022). Honey is produced in many regions of Kyrgyzstan (Kadyrova and Smanalieva,2017; İşenbaeva et al.,2021a). Buckwheat honey is a monofloral type of honey obtained from the buckwheat plant grown in Kyrgyzstan. Buckwheat honey is usually dark in colour and has a characteristic flavour and pleasant aroma. Buckwheat honey is believed to have many health benefits and is often consumed as a source of natural healing (Şabdanova et al.,2020). White honey is the honey obtained from the pollen of the sainfoin plant (Onobrychis sp.). Because it does not cause allergies, this honey is in demand on the international market (İşenbaeva et al.,2021b). In this study, the in vitro antibacterial activity of honey produced in Kyrgyzstan was investigated against important food-borne pathogens such as *Escherichia coli* and *Staphylococcus aureus*. For this purpose, two common methods such as agar-well diffusion and disc diffusion were selected and the effectiveness of these methods in the detection of antibacterial activity was compared.

MATERIAL AND METHODS

This research was carried out in the laboratories of the Department of Food Hygiene and Technology, Faculty of Veterinary Medicine, Kyrgyz-Turkish Manas University.

Honey samples: This study was carried out on 15 freshly harvested, unpasteurized, unprocessed and natural honey samples from local beekeepers operating in Kyrgyzstan. For this purpose, white honey and buckwheat honey were collected from monofloral honeys and Toktogul, Sary-Chelek and At-Bashy honey were collected from polyfloral honeys. Each sample was collected from 3 different beekeepers. The samples were placed in sterile containers and stored at room temperature in the dark until testing.

Bacterial strains: *Staphylococcus aureus* (ATCC 29213), one of the Gram-positive bacteria, and *Escherichia coli* (ATCC 25922), one of the Gram-negative bacteria, which are among the most important food-borne pathogens, were used. Bacterial cultures were incubated in Tryptic Soy Broth medium for 24 hours at 37°C and then adjusted to 0.5 McFarland turbidity (1×10^8 cfu/mL). 0,1 mL of the adjusted cultures were taken and transferred to Mueller Hinton Agar medium and spread with a sterile drigalski loop.

Disc diffusion method: The collected honey samples were weighed as 0.5 g and dissolved thoroughly by mixing with 1 ml of sterile distilled water. Samples (500 mL^{-1} dilution) were prepared in this way. Pre-prepared *E. coli* (ATCC 25922) and *S. aureus* (ATCC 29213) were inoculated with a sterile drigalski loop on Mueller-Hinton agar using the drop plate method, adjusted to 0.5 McFarland. Subsequently, 40 µL of the prepared honey sample was transferred to 6 mm diameter blank paper discs (Oxoid, England). All discs were then placed in sheets and gently pressed to ensure full contact. Sterile blank discs and discs saturated with methylene blue were used as controls. Plates were incubated for 24 hours at 37°C and the resulting zones were measured. (Patton et al.,2006).

Agar-Well diffusion method: 0,5 McFarland adjustments of each test pathogen were inoculated onto Mueller-Hinton agar using the drop plate method (Suerdem et al.,2018). Wells of 8 mm diameter were

drilled on the surface of the agar and 180 microlitres of each sample was added. Plates were incubated at 37 °C for 24 hours. The inhibition zones were measured after incubation.

Statistical analysis: The SPSS statistical analysis program (IBM SPSS, Statistics 20) was used to determine the minimum, maximum, mean and standard error using descriptive statistics.

RESULTS AND DISCUSSION

The antimicrobial activity of 15 honey samples from the Chuy region of Kyrgyzstan was analysed. The antimicrobial zones of honey by disc diffusion method are shown in Table 1. When the zones in the honeys analyzed by disc diffusion method were measured, it was found that Sary-Chelek, Buckwheat honey, Toktogul and At Bashy honey showed similar antimicrobial effects against *S. aureus*, while white honey showed the least effect. It was found that honeys analyzed by disc diffusion method showed different zones against *E.coli*. Buckwheat honey creates a zone of 9.00± 0.58 mm, Sary-Chelek honey creates a zone of 8.00± 0.58 mm, Toktogul honey creates a zone of 6.00± 0.58 mm, and the least effect is found in At Bashy honey with 4.33± 0.33 mm. Yalazi and Zorba (2020) reported that the secretion honey they collected in the Kaz Mountains region had an antimicrobial effect on *S. aureus* and *E. coli* but no effect on *Bacillus cereus, Candida albicans* and *Saccharomyces cerevisiae*. İplikçioğlu-Çil et al., (2020) reported that honey collected from different regions of Turkey had antibacterial activity against *E. coli, Listeria monocytogenes, Salmonella* Typhimurium and *S. aureus*. These findings support our research. Ramos et al., (2018) the antibacterial activity of 24 honey samples collected in Argentina was evaluated against microorganisms isolated from contaminated food. The researchers observed antimicrobial effects for most strains of *E. coli, Salmonella* spp, *S. aureus, Pseudomonas aeruginosa* and *Bacillus cereus* at 1:2 dilutions. In the same study, they reported that some honeys had no antibacterial effect at a dilution of 1:4. Çakır and Dervişoğlu (2022) prepared different concentrations (500, 250 and 125 mg mL^{-1}) of honey collected from four different districts of Bingöl province and their antimicrobial effects were investigated using the disc diffusion method. Researchers have reported that honey has antibacterial activity against *S. aureus* but not against *L. monocytogenes*. They also noted that only honey samples from Genç and Yedisu districts showed antibacterial activity against *E. coli* at a concentration of 500 mg mL-1, while other concentrations did not show antimicrobial effects. In our study, we observed antimicrobial activity against *S. aureus* in all honey samples. However, one sample from the white honey variety analysed by disc diffusion method did not show antimicrobial activity against *E. coli*, while antimicrobial effects were observed in other samples. The antibacterial activity of honey is significantly influenced by the geographical location and the botanical diversity from which the honey is obtained. Engin et al., (2022) their research found that the antimicrobial activity of monofloral honey was highest in sunflower honey. They noted that the highest inhibitory effect of monofloral honey was against S. typhimurium and that the antimicrobial effect of heat-treated honey stored in areas exposed to light decreased over time. İşenbaeva et al., (2021b) reported antibacterial activity against *E. coli, S. aureus* and *Shigella flexneri* in white honey collected in Kyrgyzstan.

Table 1. *The antimicrobial zones of honey by disc diffusion method*

	S.aureus Inhibition Zones (mm)			***E.coli Inhibition Zones (mm)***		
Type	min	max	Mean± SE	min	max	Mean± SE
Buckwheat honey	7.00	10.00	8.67±0.88	8.00	10.00	9.00± 0.58
White honey	0.00	7.00	2.33± 2.33	0.00	5.00	3.00± 1.53
Toktogul	7.00	10.00	8.33± 0.88	5.00	7.00	6.00± 0.58
At-Bashy	8.00	10.00	9.00± 0.58	4.00	5.00	4.33± 0.33
Sary-Chelek	7.00	9.00	8.00± 0.58	7.00	9.00	8.00± 0.58

The antimicrobial effects of honey using the agar well diffusion method is shown in Table 2. When the table was examined, it was found that buckwheat honey had the best effect against *S.aureus* with 18.00±0.58 mm and white honey had the least effect with 11.00±0.58 mm. Using the agar-well diffusion method, it was found that buckwheat honey, Sary Chelek and Toktogul honey had high antimicrobial effects against *E.coli*, while white honey and At-Bashy honey had the least effect.

Table 2. *The antimicrobial zones of honey by Agar-Well diffusion method*

	S.aureus Inhibition Zones (mm)			***E.coli Inhibition Zones (mm)***		
Type	min	max	Mean± SE	min	max	Mean± SE
Buckwheat honey	17.00	19.00	18.00±0.58	12.00	15.00	13.67±0.88
White honey	10.00	12.00	11.00±0.58	8.00	10.00	9.00±0.58
Toktogul	15.00	17.00	16.00±0.58	10.00	14.00	12.33±1.20
At-Bashy	14.00	16.00	15.00±0.58	10.00	11.00	10.33±0.33
Sary-Chelek	9.00	14.00	12.00±1.53	11.00	16.00	13.33±1.45

The antimicrobial effects of honeys against *S. aureus* were demonstrated using the disc diffusion and agar-well methods in Figure 1, while their antimicrobial effects against *E. coli* were shown in Figure 2. By examining both graphs, it can be observed that the honeys exhibited distinct antimicrobial effects against the selected food pathogens. This finding supports the results obtained by other researchers (Çakır and Dervişoğlu, 2022; Hulea et al.,2022; İplikçioğlu-Çil et al.,2020; Yalazi and Zorba,2020).

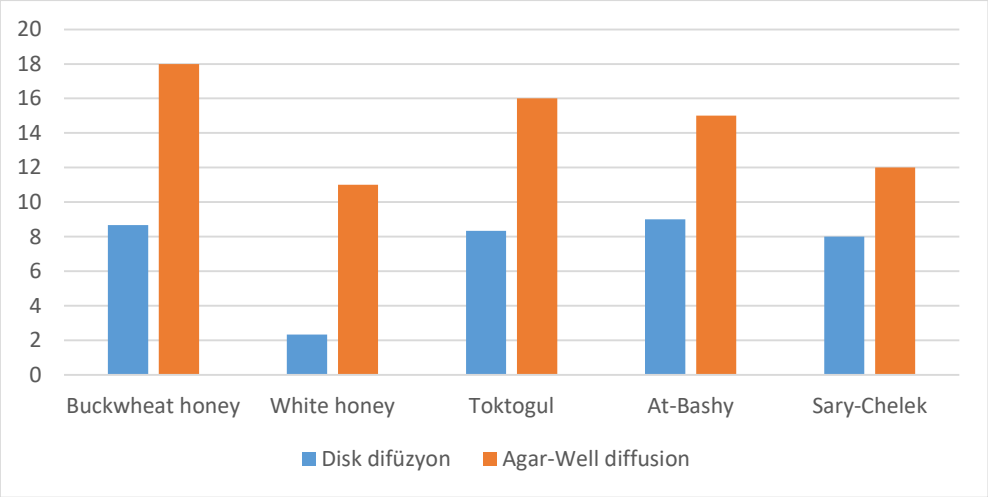

Figure 1. *Antimicrobial activity of honey against S. aureus by disc diffusion and agar-well method*

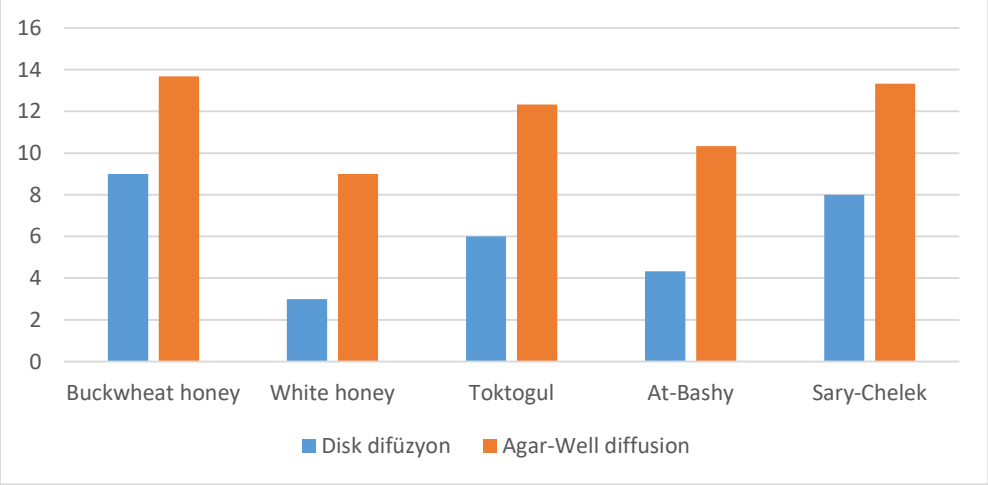

Figure 2. *Antimicrobial activity of honey against E. coli by disc diffusion and agar-well method*

CONCLUSION

Studies show that honeys from different geographical areas have significant and variable antibacterial activity against Gram-negative and Gram-positive bacteria. In the research, it was observed that both methods had antimicrobial activity against *E. coli* and *S. aureus*, which are food pathogens of choice. As a result of the analysis, the least amount of protection against pathogens was recorded in white honey samples. It is thought that this is due to the pollen collected by the bees during the production of white honey, which is a monofloral honey, and the components of the sainfoin plant (Onobrychis sp.).

Buckwheat honey showed high antimicrobial activity against both *E. coli* and *S. aureus*, as evidenced by the zones measured by both methods. This is thought to be due to the high antimicrobial activity of the constituents found in buckwheat plants. It has been concluded that the polyfloral honeys Sary-Chelek, Toktogul and At Bashy create different zones against *E. coli* and *S. aureus* due to the differing flora of the region where these honeys are collected. It can be seen that the zones formed in the disc diffusion and agar-well diffusion analyses are best obtained by the agar-well method. As a result, it is necessary to carry out research that will show the effects of honey made from the natural vegetation of Kyrgyzstan on other food-borne pathogens. The literature review revealed a limited number of scientific studies on bees and bee products in Kyrgyzstan. There is a need for further research in these areas.

CONFLICT OF INTEREST

The authors declared no conflict of interest.

AUTHOR CONTRIBUTION

All authors contributed equally.

ETHICAL APPROVAL

Scientific rules, ethics and citation rules were followed during the writing process of the study titled "**The Antimicrobial Effects of Kyrgyz Honey**". There was no tampering with the data collected and this study was not sent to any other academic publication environment for evaluation. Our study does not involve data from living animals. Therefore, ethical committee approval is not required.

NOTE

This research abstract was presented virtually as an oral presentation at the II. International Congress of Bee Science (ICbees) on 14-16 June 2023 in Kyrgyzstan.

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Research Article

Economic Impact Analysis of Value Chain Development Programme (VCDP) on Net Farm Income of Rice Farmers in Niger State, Nigeria

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ABSTRACT

This study evaluated economic impact analysis of VCDP on net farm income (NFI) of rice farmers in Niger State, Nigeria. Primary data were used. A multi-stage sampling technique was used to select a total sample size of 292 rice farmers which comprised of 155 value chain development program beneficiaries and 137 non- beneficiaries. Data were analyzed using descriptive statistics, gross margin analysis, multiple regression analysis, difference-in-difference method (DD), propensity score matching (PSM), principal component analysis, F-Chow test, and t-test. The gross margin ratio for VCDP beneficiaries and non-beneficiaries was 88% and 71%. Rice production was profitable. The result of the difference-in-difference regression analysis showed that treatment (P< 0.10), period (P< 0.01), interaction (P< 0.10), level of educational (P< 0.10), and farm experience (P< 0.10), were statistically significant variables influencing the net farm income of rice farmers in the study area. The results of PSM show that the coefficient of Average Treatment Effect for all matching algorithms for net farm income of rice farmers such as nearest neighbor, radius, kernel, and stratification were significant at (P< 0.01). The F-Chow test conducted for difference between NFI of participant and non-participant of VCDP was statistical significant. This shows that VCDP impacted positively on NFI of rice farmers. The study recommends that low-interest loans should be made available to rice farmers to increase income.

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INTRODUCTION

Rice is a rich and cheap source of carbohydrate to both human and animals, the demand for rice has increased over the last 4 decades and 80 percent of Nigerians consume rice and has become not only a diet but major source of calories for the urban poor (Ojogho and Alufohai, 2010). Rice serves as a major staple crop that cushions the effect of under-nutrition and severe hunger in Nigeria and many other developing countries of the world (Nwalieji, Madukwe, Agwu and Umerah, 2014). The demand for local rice is increasing by day as people are becoming more enlightened and informed about the nourishment. As a result of the population growth and the Federal Government Policy ban on rice importation, the Nigerian rice sector has witnessed a remarkable improvement both in terms of production, processing, and consumption. Nigerian not only being one of the largest producers is also the leading consumer of the rice in Africa and simultaneously one of the largest rice importers in the world mostly from Thailand (Emodi, and Madukwe, 2012). Rice consumption in Nigeria has been increasing over time and high percentage of the increase is supplied by imports. Between 2012 and 2015, the country imported 2.41 billion USD worth of rice in order to meet expanding consumption. The VCDP programme is a developmental initiative of FGN and IFAD with the aim to utilize private investment in the agricultural sector in order to increase efficiency and alleviate poverty (IFAD, 2017). The International Fund for Agricultural Development (IFAD) was established to finance agricultural development projects primarily for food production in the developing countries with focus on alleviating poverty of the rural dwellers through investment in agricultural activities, as agriculture is seen in the developing countries as a sector with viable potentials to move the rural poor out of poverty and with the capacity to feed the world (World Bank ,2011a).The IFAD intervention in Nigeria is focused on VCDP because of the challenges faced by smallholder farmers such as low productivity, poor access to market, poor processing technology, lack of adequate information, high costs of farm inputs, inadequate credit system, the vicious cycle of poverty and the recent challenge which has seemed formidable; climate change (World Bank, 2011b). The partnership between the IFAD and the Federal Government of Nigeria is focused on cassava and rice smallholder farmers. The six-year programme is aimed at improving cassava and rice value chains in six states in Nigeria. The IFAD/FGN adopted the value chain approach to enhance productivity, promote agro-processing, access to markets and opportunities to facilitate improved engagement of the private sector and farmers' organizations. Over 80% of the total farming population in Nigeria are smallholder farmers cultivating less than 5 hectares in the rural areas producing about 95% of the total output, yet poverty still remains a rural phenomenon with two-third of the total population considered poor (Bamidele, Olayide and Onigbide,2019). The value chain describes the full range of activities that firms and workers do to bring a product from its conception to its end use and beyond (WBCSD, 2011). The Nigerian Government has sought ways to improve productive capacity in rice production in order to become a net exporter in the future. With this in mind, the Federal Government of Nigeria and IFAD established the VCDP in 2015. The goal of the 6-year program is to improve cassava and rice value chains for small farmers in the states of Anambra, Benue, Niger, Niger, Ogun and Taraba in Nigeria. In doing this, the programme hopes to reduce rural poverty, increase food security and accelerate economic growth on a sustainable basis (VCDP, 2015). The programme utilizes a market-led approach that hinges on private sector participation to leverage investment and knowledge to drive improved productivity in rice and cassava cultivation, while continuing to promote commercially oriented smallholder farming practices.

Objectives of the Study

The broad objective analyzed economic impact of VCDP on NFI of rice farmers' in Niger State, Nigeria. The specific objectives were to:(i) determine the socio-economic profiles of rice farmers' participants and non-participants of VCDP,(ii) analyze the NFI of rice farmers' participants and non-participants of VCDP,
(iii) evaluate the impacts of VCDP on NFI of rice farmers' participants and non- participants,(iv) evaluate the factors influencing NFI of rice farmers' participants and non-participants of VCDP, and (v) determine the constraints faced by rice farmers' participants and non-participants of VCDP

MATERIALS AND METHODS

This study was carried out in Niger State, Nigeria. It lies between Latitudes 80^0 to $11^030'$ North and Longitudes 03^0 to $07^040'$ East. It has a total population of 5,556,200 (NPC, 2016). The predominant occupation of the people is farming. The crops grown in the state are rice, maize, yam, sorghum, and millet. The target population for this study areas include rice farmers of about 465 participants and 411 non-participants in the VCDP in

Niger State, Nigeria. Purposive sampling method was used to select Niger State because it is one of the State participating in the VCDP initiative of the Federal Government of Nigeria and The IFAD programme on the improvement of rice and cassava value chain. Multistage sampling procedure was adopted in selection of representative samples. First stage, five (5) Local Government Areas were selected. The second stage, simple random sampling technique using raffle-draw ballot-box raffle-draw method was adopted to select the two (2) wards from each of the five (5) Local Governments Areas. In the third stage, systematic sampling techniques was used. Firstly, simple random sampling was used to selects the first respondents, subsequently; systematic sampling was used to select every n^{th} (3^{rd}) rice farmers participating in the VCDP from the list of registered rice farmers obtained from the baseline survey. A total sample size of 292 rice farmers was selected comprising of 155 beneficiaries and 137 non-beneficiaries of VCDP. The total target population of rice farmers' beneficiaries and non-beneficiaries was 876. Primary and secondary data were used to gather necessary data from the sample respondents.The following analytical tools were used to achieve stated objectives:

Descriptive Statistics

Descriptive statistics involves the use of mean, mode, range, frequency distribution tables and percentages, minimum and maximum values and standard deviations.

Gross Margin Analysis

Gross Margin Analysis is by definition the difference between total revenue and total variable cost (Olukosi and Erhabor, 2005). Gross margin model is expressed as follows:

$$GM = \sum_{i=1}^{n} TR_i - \sum_{i=1}^{n} TVC_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where,
GM = Gross Margin (Naira),
TR = Total Revenue or Total Value of Output from the Rice Enterprise (Naira),
TVC = Total Variable Cost (Naira), and
TR = P.Q (Naira).
Where: -P = Price of Rice Produced in Naira per Kilogram, Q = Output of Rice Produced in Kilogram.

Financial Analysis

Gross Margin Ratio (GMR) following Ben-Chendo *et al*. (2015) was used to determine the profitability of rice production.

$$\boldsymbol{Gross\ Margin\ Ratio} = \frac{Net\ Farm\ Income}{Total\ Revenue} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Net Farm Income Analysis

$$NFI = TR - TC \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$\%\ Change\ in\ Net\ Farm\ Income\ (NFI) = \frac{NFI_{After} - NFI_{Before}}{NFI_{After}} \times 10 \ldots\ldots\ldots\ldots\ldots (4)$$

Where,
NFI = Net Farm Income (Naira),
TR = Total Revenue (Naira), and
TC = Total Cost (Naira).

Double Difference Method / Difference-in –Difference Method (DD)

The impact assessment method involved the selection of respondents that participated in rice VCDP (beneficiaries) and non-participants (non-beneficiaries). The model can be explicitly specified as follows:

$$DD = \left[\frac{1}{P}\sum_{t=1}^{P}(Y_{ta}^{1} - Y_{tb}^{1})\right] - \left[\frac{1}{C}\sum_{i=1}^{C}(Y_{ta}^{0} - Y_{tb}^{0})\right] \dots\dots\dots\dots\dots\dots\dots\dots (5)$$

Where,
DD = NFI Difference between Respondents (Units),
P = Number of Participants (Units),
C = Number of Non-Participants (units),
Y_{ta}^{1} = NFI of Participants after the Programme (Naira),
Y_{tb}^{1} = NFI of Participants before the Programme (Naira),
Y_{ta}^{0} = NFI of Non-Participants after the Programme (Naira), and
Y_{tb}^{0} = NFI of Non-Participants before the Programme (Naira).

Multiple Regression Analysis

The double difference analysis of the multiple regression model for participants and non-participants of rice farmers VCDP is stated below: -

$$Y = \propto_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \mu_i \dots\dots\dots (6)$$

Y = Net Farm Income (Naira),
α_1 = Intercept,
$\beta_1 - \beta_{11}$ = Regression Coefficients,
X_1 = Treatment (T) (1, Beneficiaries; 0, Otherwise),
X_2 = Period (P) (Months),
X_3 = Interactions (T x P) (Units),
X_4 = Age of Rice Farmers (Years)
X_5 = Level of Education (0, Non-Formal; 1, Primary; 2, Secondary; 3, Tertiary),
X_6 = Extension Agent Service Dummy (1, Contact; 0, Otherwise),
X_7 = Household Size (Units),
X_8 = Farm Experience (Years),
X_9 = Access to Credit Facilities (1, Access; 0, Otherwise),
X_{10} = Member of Cooperative Societies (1, Member; 0, Otherwise), and
X_{11} = Gender (1, Male; 0, Otherwise), and
U_i= Error Term.

Propensity Scoring Matching (PSM)

PSM was employed to determine the impact of VCDP on the NFI of the participants of the programme; usually the propensity score matching is used in programme evaluation to access whether the programme has impact on the participants. The most common evaluation parameter of interest is the Average Treatment Effect on the treated (ATT) which is defined as: -

$$ATT = E\left(\frac{Y_1 - Y_0}{P = 1}\right) - \left(\frac{Y_1}{P = 1}\right) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (7)$$

The propensity score is the probability of the participation for farm households, if given a set $X = X_i$ of characteristics.

$$P(X) = P_r\left(\frac{P = 1}{X = X_i}\right) \text{ (Pufahl and Weiss, 2009)} \dots\dots\dots\dots\dots\dots\dots\dots (8)$$

The propensity scores were derived from the regression model in which these characteristics were compared. The impacts of treatment on the treated (causal effect of project participants) were estimated by computing the differences across both groups:

$$ATT = \frac{1}{N_1}[Y_1 - Y_0] \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (9)$$

Where,
ATT = Average Impact of Treatment on the Treated,
N_1= Number of Matches (From Regression Model),
Y_1= Productivity Index by Participants, and
Y_0= Productivity Index by Non-Participants.
A positive (Negative) value of ATT will usually suggest that beneficiaries in a programme have higher (lower) outcome variable than non-beneficiaries. This was used to achieve specific objective four (iv)

Principal Component Analysis (PCA)

The constraints faced by rice farmers participating in the VCDP was achieved using principal component tools (PCA).

F-chow Test

F-chow Test statistics is often used in programme evaluation to determine whether the programme has impacts on different subgroup population. Chow Test is an application of the F-distribution test, if F-chow is greater than the F-table, then there is a projects impact on the beneficiaries otherwise, there is no impact. The model is specified as follows:

$$\mathrm{F} * -\mathrm{Chow\ Test} = \frac{RSS-(RSS_1+RSS_2)/K}{RSS_1+RSS_2/[\mathrm{N}_1+\mathrm{N}_2-2K]} \ldots\ldots\ldots \quad (10)$$

Where,O
RSS = Sum of Square Residual from Pooled Data,
RSS_1 = Sum of Square from the First Group (Beneficiaries),
RSS_2 = Sum of Square from the Second Group (Non-Beneficiaries),
K = Total Number of Parameter,
N_1, N_2 = Number of Observation in Each Group

RESULTS AND DISCUSSION

Socio-Economic Profiles of Rice Farmers VCDP Beneficiaries and Non-Beneficiaries

Table 1 shows that the mean age of rice farmers' beneficiaries was 46 years. The non-beneficiaries had a mean age of 51 years, when combined the mean age was 49 years. This implies that most of the rice farmers were middle-aged, resourceful, and energetic in their economically active age. Farmers' age is said to influence farmers' maturity and decision-making ability (Sani *et al.*, 2014). The results show that younger farmers are agile, and able to adopt modern production technologies with potential high productivity. This finding is similar to that of Sani *et al.* (2014). About 55.48% of the beneficiaries had less than 10 people as members of households. The mean household sizes were 13, 11, and 12 people for beneficiaries, non-beneficiaries, and when combined respectively. This has a direct implication on labor supply to the farm because of the potential contributions to labor available for rice production. The results agree with the findings of Sani *et al.* (2010) and Fakayode *et al*. (2014). The mean years of experience were 22 years, and 18 years for beneficiaries, and non-beneficiaries respectively. According to Olaoye *et al*. (2013) number of years of experience could improve skills and better approaches to rice farming practices. Experience can help to correct past errors and expand or contract the scale of the applications of tested skills. This result is in line with findings of Bashir *et al.* (2018). Also, the rice farmers had formal education, the expectations are rice farmers had formal education given that the respondents had attained at least 6 years in school. This agrees with the findings of Olagunju *et al.* (2010).

Table 1. *Socio-Economic Profiles of Rice Farmers VCDP Participants and Non-Participants*

Variables	Beneficiaries	Non-Beneficiaries	Pooled
Age (Years)	51	46	49
Household Size (Number)	13	11	12
Farm Experience (Years)	22	18	20
Level of Education (Years)	12	8	10

Source: Field Survey (2020)

Net Farm Income Analysis of Rice Production among VCDP Beneficiaries and Non-Beneficiaries per farming season

The various costs incurred on various resources used and the benefits (profit) received from the sales of the products were estimated based on the market price at the period under consideration (2019/2020 farming season) is presented in Table 2. The total revenue for program beneficiaries and non-beneficiaries was estimated to be ₦698, 400.00 and ₦381, 600.00 respectively. The total variable cost for program beneficiaries and non-beneficiaries was estimated to be ₦180, 528.41 and ₦151, 821.70 respectively. The fixed cost for program beneficiaries and non-beneficiaries was estimated to ₦39, 625.26 and ₦19, 000.00 respectively. The variable cost for program beneficiaries and non-beneficiaries accounted for 85% and 80% of the total cost of production. The gross margin for program beneficiaries and non-beneficiaries was estimated to be ₦517, 871.59 and ₦229,778.30 respectively. On average both program beneficiaries and non-beneficiaries made a NFI of ₦ 478, 246.33 and ₦210,778.30 respectively per hectare of rice production. The gross margin ratio for program beneficiaries and non-beneficiaries was 74% and 60% respectively. This indicates that rice production was profitable. This implies that for every one Naira generated from sales by smallholder rice farmers that benefitted and non-beneficiaries of the program, 74.00 kobo and 60.00 kobo covered the operating costs and profit respectively. This suggests that rice production by the program beneficiaries were more profitable than non-beneficiaries

Table 2. *Net Farm Income Analysis of Rice Production for Beneficiaries, Non-Beneficiaries per Farming Season*

Variables	Beneficiaries	Non-Beneficiaries	Pooled
Total Variable Costs (Naira)	180,528.41	151,821.70	332,350.11
Total Fixed Cost(Naira)	39,625.26	19,000.00	58,625.26
Total Cost (Naira)	220,153.67	170,821.70	390,975.37
Quantity (Kg)	3,492.00	1,908.00	5,400.00
Unit Price (Naira/Kg)	200	200	200
Total Revenue (Naira)	698,400.00	381,600.00	1,080,000.00
Gross Margin (Naira)	517,871.59	229,778.30	747,649.89
Net Farm Income (NFI) (Naira)	478,246.33	210,778.30	689,024.63
Gross Margin Ratio (Unit)	0.74	0.60	0.69

Source: Field Survey (2020) 1 USD = 820 NAIRA

Difference-in-Difference Estimation of Impacts of VCDP on NFI of Rice Farmers Beneficiaries and Non-Beneficiaries

From Table 3 the NFI difference between rice farmers' beneficiaries and non-beneficiaries' groups were ₦5, 481.4477 before the program and this increased by 97.95% to 267,468.03 after the program. This suggests that the program had a positive impact on the income of the beneficiaries of the program. Also, the between group effect shows that the NFI of beneficiaries and non-beneficiaries increased by 76.69% and 49.73%. This further suggests that the program had a positive impact on the income of the beneficiaries of the program hence the beneficiaries may be more food secured given their participation in the value chain program. The NFI difference in difference was calculated to be ₦261, 986.58**.** The F-value (321.01) confirmed that there was a significant difference between net farm income of rice farmers' beneficiaries and non-beneficiaries of VCDP at 1% probability level**.** This result is in line with the findings of Olaoye *et al*, (2013) and Zalkuwi (2015) who both found out that rice production was profitable.

Table 3. *Double Difference Result of Impacts of VCDP on Net Farm Income of Rice Farmers Beneficiaries and Non-Beneficiaries*

Group	Net Farm Income (Naira)		
	Before	After	Difference Between Period
Beneficiaries	111, 436.5253	478, 246.33	366.809.80
Non-Beneficiaries	105, 955.0776	210,778.30	104,823.22
Difference Between Groups	5, 481.4477	267,468.03	**261,986.58**
F-Value = 321.01***			

Source: Field Survey (2020**)** ***-Significant at 1 percent probability level

Difference-in-Difference Method of Regression Analysis of the Impacts of VCDP on Net Farm Income of Rice Farmers Beneficiaries and Non-Beneficiaries

Table 4 shows the estimated difference-in-difference method of regression analysis of the impacts of VCDP on NFI of rice farmers beneficiaries and non-beneficiaries. From the result, variables with positive coefficient leads to increase in NFI while variables with negative coefficient leads to decrease in net farm income. Coefficient of determination (R^2) was approximately 0.7912 which means that 79.12% of the variations in the NFI of the rice farmers was as a result of the variations in the explanatory variables included. The F-Statistics value of 96.47 was significant at 1% probability level. This implies that the joint effect of the variables included in the model were significant in determining net farm income. The results showed that treatment (X_1), period (X_2), interaction (X_3), level of educational (X_5), and farm experience (X_8) were statistically significant variables influencing the net farm income of rice farmers in the study area. Level of educational (X_5) and farm experience (X_8) had positive coefficients and were statistically significant at 10% probability levels ($P < 0.10$). Treatment (X_1), period (X_2), and interaction (X_3) had positive coefficients and were statistically significant 10%, 1%, and 10% probability levels respectively. From the regression result, the treatment (X_1) was positively related to NFI of rice farmers. This suggest that the program had a positive impact on the income of farmers in the study area. Period (X_2) was positively related to net farm income. Interaction (X_3) was positively related to net farm income. The statistical significant of interaction (X_3) implies that the VCDP impacted positively on the rice farmers' participant.

Table 4. *Double Difference Estimate from Regression Analysis of the Impacts of VCDP on NFI of Rice Farmers Participants and Non-Participants*

Variables	Coefficients	Standard Error	t-Value
Treatment (X_1)	0.1312	0.1903	1.69*
Period (X_2)	0.5559	0.1708	3.25***
Interaction (X_3)	0.2113	0.1193	1.77*
Age (X_4)	0.1062	0.1322	0.8
Educational Level (X_5)	0.0911	0.0501	1.82*
Extension Contact (X_6)	0.0240	0.0535	0.45
Household Size (X_7)	-0.0199	0.0455	-0.44
Farm Experience (X_8)	0.0585	0.0504	1.67*
Access to Credit (X_9)	0.0040	0.0475	0.08
Member of Cooperative Society (X_{10})	0.0198	0.0472	0.42
Gender (X_{11})	0.0313	0.0463	0.68
Constant	12.3284	0.5264	23.42
R-squared	**0.7912**	**Adj R^2**	**0.7830**
F Statistic	**96.47**		

Source: Field Survey (2020)

Table 5. *Average Treatment Effect of Before and After Bootstrap on NFI of Rice Farmers*

Matching Algorithm	ATT	Standard Error Before Bootstrap	Standard Error After Bootstrap	Bias	t-Value
Nearest Neighbour	446, 000	115, 000	145, 068.4	-36, 961.45	3.076 ***
Radius	331, 000	132, 000	88, 269.622	-16, 173.44	3.752 ***
Kernel	347, 000	-	95940.82	4, 784.654	3.612***
Stratification	378, 000	108, 000	109, 034.6	6, 914.596	3.464 ***

Source: Field Survey (2020)

Propensity Score Matching of the Impacts of VCDP on Income of Rice Farmers

Table 5 shows the PSM of the impacts of VCDP on NFI of rice farmers. The coefficient of ATT for nearest neighbour, radius, kernel, and stratification were positive. All the matching algorithms were significant at 1%

probability levels. This implies that the VCDP had significant impact on income of rice farmers' beneficiaries. The value of ATT for nearest neighbour, radius, kernel, and stratification were 446, 000, 331, 000, 347, 000, and 378, 000 respectively. They were all statistically significant at ($P < 0.01$) respectively.

Constraints Faced by Rice Farmers' Beneficiaries of VCDP

Principal Component Analysis is a statistical technique that transfers a data set with many interrelated variables into one with a smaller number of uncorrelated variables. From the result presented in Table 6, the number of principal components retained using the Kaiser criterion was four (4) which had an Eigen-value above 1. At this component, for beneficiaries of VCDP, 58% of the variations have been explained by the component captured in the model. The Kaiser-Meyer-Olkin which measures of sampling adequacy (KMO) was 0.515 and Bartlett test of sphericity was 80.579 and significant at a 1% level of probability which further demonstrated the feasibility of employing the data set for factor analysis. The result in Table 6 further shows the constraints faced by rice farmers' beneficiaries of the VCDP as identified by the farmers include: herdsmen and farmers-clashes which was rank 1st in the order of importance based on the perceptions of the rice farmers with 19% proportion. Inadequate funds were ranked 2nd in the order of importance based on the perceptions of the rice farmers with 14%. Bureaucracy in accessing credit was ranked 3rd in the order of importance based on the perceptions of the rice farmers with 13%. Inadequate fertilizers were ranked 4th in the order of importance based on the perception of the rice farmers with 11%. The results agreed with that of Bashir *et al.* (2018).

Constraints Faced by Rice Farmers' Non-Beneficiaries of VCDP

The constraints facing rice farmers' non-beneficiaries of VCDP was presented in Table 6. The number of principal components retained using the Kaiser criterion was four (4) which had an Eigen-value greater than 1. At this component, for non-beneficiaries of VCDP, 59% of the variations have been explained by the component retained in the model. The Kaiser-Meyer-Olkin which measures of sampling adequacy (KMO) was 0.529 and Bartlett test of sphericity of 67.484 and was significant at a 1% level of probability which further demonstrated the feasibility of employing the data set for factor analysis. The result in Table 6 further shows the constraints faced by rice farmers' non-beneficiaries of the VCDP as identified by the farmers include: herdsmen and farmers-clashes which was rank 1st in the order of importance based on the perceptions of the rice farmers with 18% proportion. Inadequate funds were ranked 2nd in the order of importance based on the perceptions of the rice farmers with 16%. Bureaucracy in accessing credit was ranked 3rd in the order of importance based on the perceptions of the rice farmers with 14%. Inadequate fertilizers were ranked 4th in the order of importance based on the perception of the rice farmers with 12%. The results also agreed with that of Bashir *et al.* (2018).

Analysis of the Significant Impact of VCDP on Net Farm Income of Rice Farmers

Table 7 revealed the F-chow-test analysis between impact of VCDP on NFI of rice production. Based on the findings of this study, the hypothesis which states that there is no significant impact of VCDP on NFI of rice production was rejected, while the alternative hypothesis which states that there is significant impact of VCDP on NFI of rice production was accepted. This implies that the VCDP had impact on the NFI of rice farmers.

Table 6. *Principal Component Analysis of Constraints Faced by Rice Farmers in Niger State, Nigeria*

	Beneficiaries			Non-Beneficiaries			Combined		
Component	**Eigen-Value**	**Proportion**	**Cumulative**	**Eigen-Value**	**Proportion**	**Cumulative**	**Eigen-Value**	**Proportion**	**Cumulative**
Herdsmen's and Farmer Clashes	1.74	0.19	0.19	1.63	0.18	0.18	1.63	0.18	0.18
Inadequate Funds	1.28	0.14	0.33	1.41	0.16	0.34	1.28	0.14	0.32
Bureaucracy in Accessing Credits	1.18	0.13	0.46	1.21	0.14	0.47	1.17	0.13	0.45
Inadequate Fertilizer	1.02	0.11	0.58	1.05	0.12	0.59	1.09	0.12	0.57
Pest and diseases	0.97	0.10	0.68	0.89	0.10	0.69	0.94	0.11	0.68
Poor Access to Extension Agent	0.87	0.09	0.78	0.82	0.09	0.78	0.84	0.09	0.77
Distance to the Market	0.72	0.08	0.86	0.74	0.08	0.86	0.76	0.08	0.85
High Cost of Labour	0.69	0.08	0.94	0.65	0.07	0.94	0.69	0.07	0.93
High Cost of Maintenance	0.49	0.05	1.00	0.55	0.06	1.00	0.57	0.06	1.00
Bartlett Test of Sphericity	**Chi-Square = 80.579*** KMO = 0.515**			**Chi-square = 67.484*** KMO = 0.529**			**Chi-square = 122.849*** KMO = 0.520**		

Source: Field Survey (2020)

Table 7. *F-Chow – Test Analysis of Impact of VCDP on Net Farm Income of Rice Farmers*

Group Sample	R^2	Residual Sum of Square	N	K	F-Cal	F-Tab	Prob
Pooled	0.0968	21.029	292	3	10.29	1.96	0.0000
Participants	0.1770	12.003	155	3	10.82	1.96	0.0000
Non-Participants	0.0599	8.1473	137	3	2.82	1.96	0.0413
***, Significant at 5% level of Probability**							

Source: Field Survey (2020)

CONCLUSION AND RECOMMENDATIONS

This study has established that rice farmers' beneficiaries of VCDP were young, energetic, and resourceful. The VCDP had impacted positively on the net farm income of rice farmers. The policy implications and recommendations from this study include:

(i) Provision of extension officers to train rice farmers on new technologies, innovation, and new research findings.

(ii) Rice farmers should be provided with credit facilities at low interest rate with no collateral securities. This will enable the farmers improve productivity and hence net farm income.

(iii) Rice farmers should be provided with farm inputs and improved varieties of rice. This will increase rice production and hence net farm income.

(iv) Governments are hereby enjoyed to put policy in place that will help remove administrative bottle necks in accessing agricultural loans.

CONFLICT OF INTEREST

The authors declared that there is no conflict of interest.

AUTHOR CONTRIBUTION

All authors contributed equally towards this publication.

ETHICAL APPROVAL

There is full compliance with ethical stamdards. No ethical issues raised.

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Research Article

Investigation of Germination and Early Seedling Development of Some Flax (*Linum usitatissimum* L.) Seeds Under Salt Stress

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ABSTRACT

Salinity, one of the abiotic stress factors, causes various physiological damages in plants. Salt stress significantly affects plant growth and development. One of the ways to reduce the negative effect of salt stress, which has a limiting effect on plant growth, is to determine the tolerance level of plants. This study was carried out under controlled conditions in order to examine the effect of salt stress on the germination of flax plant, which is one of the important industrial plants with various usage areas around the world. In this study, 3 flax varieties (Somme, Midin and Norman) and 4 salt concentrations (control, 50 mM, 100 mM and 200 mM) were used. In this experiment, germination rate, radicle length, plumula length, seedling length and seedling fresh weight characteristics of seeds under salt stress were examined. Statistically significant differences were detected between all the properties examined in the study, both among the cultivars and the salt doses. The study revealed that the control (pure water) group obtained the highest values in all the examined properties, but these values significantly decreased as the salinity severity increased. It was determined that the 200 mM salt dose significantly affected the germination of flax. 'Somme' flax variety was the most tolerant variety against salt doses in terms of the properties examined.

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Tuz Stresine Maruz Bırakılan Bazı Keten (*Linum usitatissimum* L.) Tohumlarının Çimlenme ve Erken Fide Gelişiminin Araştırılması

ÖZET

Abiyotik stres faktörlerinden biri olan tuzluluk, bitkilerde birçok fizyolojik hasarlara yol açmaktadır. Tuz stresi bitki büyüme ve gelişmesinde önemli bir rol oynar. Bitki gelişimini sınırlayıcı etkiye sahip olan tuz stresinin olumsuz etkisini azaltmanın yollarından biri de bitkilerin tolerans düzeyinin belirlenmesidir. Bu çalışma, dünyada birçok kullanım alanına sahip önemli endüstri bitkilerinden biri olan keten bitkisinin tuz stresi altında çimlenme ve fide gelişimi üzerine olan etkisini incelemek amacıyla kontrollü şartlar altında yürütülmüştür. Çalışmada 3 adet keten çeşidi (Somme, Midin ve Norman) ve 4 adet tuz konsatrasyonu (kontrol, 50 mM, 100 mM ve 200 mM) kullanılmıştır. Araştırmada tuz stresine maruz bırakılan tohumların çimlenme oranı, radikula uzunluğu, plumula uzunluğu, fide boyu ve fide yaş ağırlığı parametreleri incelenmiştir. Araştırmada incelenen tüm özelliklerde hem çeşitler hem de tuz dozları arasında istatistiksel olarak önemli farklılıklar tespit edilmiştir. Çalışma sonucunda incelenen tüm özelliklerde en yüksek değerler kontrol (saf su) grubundan elde edilirken, tuzluluk şiddeti arttıkça bütün değerlerde düşüşler meydana gelmiştir. Ayrıca, 200 mM tuzluluk dozunun keten çimlenmesini önemli ölçüde etkilediği çalışmanın sonuçları arasında yer almaktadır. İncelenen özellikler açısından 'Somme' keten çeşidi tuz dozlarına en toleranslı çeşit olmuştur.

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INTRODUCTION

Flax (*Linum usitatissimum* L. 2n=30) is one of the self-pollinated oilseed plants that complete the vegetation period in one year. While oil is obtained from the seeds of flax, fiber is obtained from the stem of some forms. Flax is one of the oldest plants cultivated for its fiber as well as its oilseed (Dubey et al. 2020). Flax seeds contain approximately 40-45% oil and this oil is used in various industrial fields such as making paints, soaps, varnishes, and printer ink (Cloutier et al. 2009). The oil obtained from flax seeds is widely used in the paint and flooring industry, as it dries faster than other vegetable oils (Bayrak et al. 2010). Flax oil has also been recognized as an excellent source of micronutrients. It is also known to be rich in dietary fiber, protein, vitamin B1, lignin and linoleic acids, which are essential fatty acids (Kajla et al. 2015; Goyal et al. 2016). Although flax, which is not very selective in terms of soil properties, can be grown easily in most soil types, it is adversely affected by heavy textured soils with poor drainage. The plant can easily grow in soils with a pH between 6 and 6.5. The vegetation period of flax is short. Although the vegetation period varies according to the variety and the geographical conditions in which it is grown, it completes its development in an average of 90 to 120 days. Since the life cycle of the plant is short, it ensures that two crops are taken from the same field in one year. Therefore, it can be considered as a good rotation plant. The adaptation of flax to different climatic areas is high. The climate requirements of flax differ according to the purpose of cultivation (for fiber or seed purposes). Particularly subtropical areas are more suitable for the seed production of flax, which is widely distributed in humid areas with a mid-belt climate. Humid climatic regions are important for flax cultivation, and especially cool, frequent rainy, coastal areas (in fiber-purpose cultivation) are very ideal.

Salinity stress, to which plants are exposed, causes an increase in osmotic pressure and a deterioration of the balance in ion uptake (Tahjib-Ul-Arif et al. 2018). Plants are adversely affected by salinity stress at all stages of growth. Response to salinity stress varies not only between plant species but also between different varieties of the same species (Bojović et al. 2010). Wang et al. (2009) reported that many plant species are more sensitive to salinity during the early stages of growth, such as germination and seedling formation stages. The severity of salt stress and the resistance of the plant to salinity are first determined during the germination and seedling growth stages, because the rapid and uniform emergence of seedlings is an important prerequisite for obtaining efficient and high quality crops (Sadeghi and Robati 2015). Misra and Dwivedi (2004) reported that the germination phase is the most critical growth period in plants and that plants are greatly affected by salinity during this phase.

In this study, the resistance of flax, an important alternative oil plant, to salt stress during germination and early seedling growth stages was investigated.

MATERIAL AND METHODS

This study was carried out under controlled conditions to determine the effects of salt doses applied to three different flax varieties (Norman, Somme, Midin) on the germination and early seedling development stages of seeds. The study was carried out in three replications according to the factorial experimental design in random plots. In the study, double-layered Whatman paper was placed in sterilized petri dishes for each application and 30 flax seeds sterilized in a 10% NaCl solution were placed in each petri dish. Petri dishes were left open for a while to dry the seeds placed in 11 cm diameter petri dishes. After the seeds dried, 7 mL of the prepared salt concentrations were added to them (Moghaddam et al. 2018). The same amount of distilled water was added to the control group. The salinity concentrations were prepared as 0 (control group), 50, 100 and 200 mM, which were determined based on previous studies (Moghaddam et al. 2018). Petri dishes were wrapped with parafilm to prevent moisture loss due to evaporation. The prepared petri dishes were left to germinate in the climate cabinet at 25 °C at 70% relative humidity and the germinated seeds were counted at the same time every day (every 24 hours) for 7 days (Bilgili et al. 2011). In the experiment, seeds with a radicle of 2 mm were considered germinated (Mostafavi 2012). In the study, radicle length, plumula length, seedling length seedling fresh weight and germination rate were measured. The germination rate was calculated by dividing the the number of germinated seeds by the total number of seed then multiplying them by 100 (Maquire 1962). For seedling lengths, radicle and plumule lengths were measured separately, and then the seedling length was determined by adding both lengths (ISTA 1984). The radicle and plumule were weighed and the fresh weights of the seedlings were determined. The data obtained from the study and variance analyses were performed

using the JMP statistical package program, and the differences between the means and multiple comparisons were calculated according to the LSD test.

RESULTS AND DISCUSSION

In this study, the effects of different salt concentrations on the germination and seedling development periods of some flax (*Linum usitatissimum* L.) cultivars were investigated. In the study, it was observed that there were significant differences in terms of radicle length, plumula length, seedling lenght, seedling fresh weight and germination rate ($P<0.05$).

Significant differences between cultivars and doses in terms of radicle length can be seen in Table 1. From the table, it is seen that flax seeds belonging to different varieties are adversely affected by increasing salt stress, and radicle length decreases as the severity of salinity increases. While the maximum radicle length was obtained from the control group, the lowest average value was obtained from the highest salt concentration of 200 mM. While the Somme variety had a radicle length of 91.30 mm in the control group, this value decreased as the intensity of the doses increased. Norman variety was the most affected variety in terms of radicle development at 200 mM salt concentration. Since plant roots are in direct contact with the soil, they take water and nutrients from the soil and transmit them to the upper parts of the plant. Therefore, root development is one of the most important parameters in terms of salt stress (Moghaddam et al. 2018). Jamil et al. (2006) reported that root and shoot lengths provide important clues in the response of plants to salt stress. Moghaddam et al. (2018) investigated the responses of some flax varieties to salt stress. In their study, they stated that the best development in terms of radicular length was obtained from the control group and that radicula development slowed down as the severity of salinity increased. Abido and Zsombik (2019) reported that the length of the radicle was changed at different salt doses and that the radicular length clearly decreased as the salt intensity increased.

In terms of plumula length, the interaction of doses and varieties was found to be statistically significant (Table 1). While the highest plumule length was obtained from the control group, as the severity of salinity increased, the stem length value also decreased and got the lowest value at the highest salt dose of 200 ppm. When the effect of salt stress on cultivars was examined, all cultivars used in the experiment showed the best results in terms of plumule length in the control group. The Norman variety was the variety most affected by salinity, with the lowest value at 200 ppm. In the studies of the researchers on the seedling development of flax, it was stated that the radicle and plumule length of the seedlings were significantly affected by 150 and 200 mM salt concentrations (Zaghdoudi et al. 2015; Yaver and Pasa 2009; Muhammad and Hussain 2010; Kadkhodaie and Bagheri 2012). Moghaddam et al. (2018) reported that as the salinity intensity increases, plumule length decreases and plumule development slows down considerably at 12 dS/m salinity dose. Kadkhodaie and Bagheri (2012), in their study in which they examined the seedling growth parameters of flax seeds under salt stress, stated that flax seeds exposed to high concentrations showed a slowdown in plumule development.

In the study, seedling length was examined to determine the effects of salt doses on seedling development (Table 1). The effect of salt doses on the development of seedling length of flax seedlings was found to be statistically significant ($P<0.05$). When the effect of salt doses on cultivars was examined, it was observed that the highest seedling length was obtained from the control group, and as the salinity concentrations increased, significant decreases in seedling length occurred. At the highest salt concentration (200 mM), serious reductions in seedling length occurred and Midin variety was the variety with the lowest seedling growth. Kaya et al. (2012) studied the response of some linen lines to salt stress. In their study, they reported that varieties showed significant differences in terms of germination parameters at different salt doses and that seedling growth slowed down significantly at 20 dS/m, the highest salt concentration. El-Nakhlaway and El-Fawal (1989) reported that salt stress significantly reduced germination and seedling growth in flax plant development. The reason for the slowdown in germination is due to the osmotic stress that occurs with the effect of ion exchange at increasing salt levels (Almansouri et al. 2001; Kaya et al. 2006; Atak et al. 2006).

Table 1. *Radicle length, plumula length, seedling length values of flax seeds at different salt concentrations*

Radicle length (mm)				
Dose/ Variety	**Somme**	**Midin**	**Norman**	**Average**
Control	91.30^{a}	48.39^{cd}	52.67^{c}	64.12^{A}
50 mM	69.33^{b}	34.63^{ef}	40.95^{de}	48.30^{B}
100 mM	30.84^{fg}	22.15^{gh}	14.73^{hı}	22.57^{C}
200 mM	11.75^{ı}	10.42^{ı}	4.30^{j}	7.39^{D}
Average	50.80^{x}	28.89^{y}	27.09^{y}	
CV (%)	16.01			
LSD$_{(0.05)}$	V: 4.47*	D:5.21*	V x D : 7.99*	
Standard Error	V: 1.650	D: 1.901	V x D: 3.301	
Plumula length (mm)				
Dose/Variety	**Somme**	**Midin**	**Norman**	**Average**
Control	103.09^{a}	74.93^{b}	105.02^{a}	94.35^{A}
50 mM	88.05^{ab}	45.31^{c}	79.51^{b}	70.96^{B}
100 mM	27.83^{cd}	29.12^{cd}	17.43^{de}	24.79^{C}
200 mM	10.75^{de}	11.10^{de}	3.90^{e}	7.28^{D}
Average	57.43	40.11	50.49	
CV (%)	24.62			
LSD$_{(0.05)}$	V: N.S	D : 22.98*	V × D: 39.80**	
Standard Error	V: 3.269	D:4.878	V × D: 6.538	
Seedling length (mm)				
Dose /Variety	**Somme**	**Midin**	**Norman**	**Average**
Control	194.39^{a}	123.32^{c}	157.70^{b}	158.47^{A}
50 mM	157.39^{b}	79.94^{d}	120.46^{c}	119.26^{B}
100 mM	58.67^{de}	51.27^{ef}	32.16^{fg}	47.37^{C}
200 mM	22.50^{gh}	21.52^{gh}	7.81^{h}	14.67^{D}
Average	108.24^{x}	69.01^{y}	77.58^{y}	
CV (%)	19.56			
LSD$_{(0.05)}$	V: 17.18*	D: 36.98*	V × D : 63.48*	
Standard Error	V: 4.224	D:4.878	V × D: 8.449	

* and **:significant at P ≤ 0.05 and P ≤ 0.01 respectively. N.S: No significant. a, b, c...; varieties × doses, A, B.C...; average of doses, x, y, z... ; average of varieties

The effects of salt doses on seedling fresh weight were given in Table 2 and it was determined that there was a statistical difference between salt doses in terms of seedling fresh weight (P<0.05). The effect of salt doses in the experiment on the seedling fresh weight of flax seedlings was investigated. It was determined that the highest fresh seedling weight was obtained from the control group and the seedling fresh weight decreased significantly as the intensity of the doses increased. Moghaddam et al. (2018) reported that seedling fresh weight in flax decreased significantly with increasing salinity doses, and seedling fresh weight was the highest in control and 50 mM. Similarly, Jamil et al. (2006) reported that the seedling fresh weight (shoot + root) of flax was affected by all salt doses (4.7-14.1 dS/m) and the shoot fresh weight decreased more than the root fresh weight. High salinity in the environment causes an increase in osmotic pressure. This situation causes imbalances in the water uptake of the seed and slows down both the germination of the seed and the development of the germinated seeds (Rajabi and Postini 2005). The increase in osmotic pressure (more negative osmotic pressure) caused by environmental salinity prevents the water uptake of the seed. This situation both disrupts the hydration balance of the seed and prevents seed germination by creating toxic effects of cations and anions in high amounts in the environment.

The effects of salt doses on germination rate are given in Table 2 and it was determined that there was a statistical difference between salt doses and varieties in terms of germination rate (P <0.01). Germination rate of all cultivars decreased with increasing salt doses. At the highest salt concentration (200 mM), the germination rate was severely reduced. Moghaddam et al. (2018) reported that different salt concentrations affect the germination parameters of flax, while increasing salt doses significantly affect germination. Many researchers have reported that the increase in salt levels has a negative effect on the germination of flax seeds (Jamil et al. 2006; Vicente et al. 2007; Mohammadizad et al. 2013). Abbasian and Moemeni (2013) explained the reason for the decrease in germination with the increase in salinity level, with the increase of toxic ions in

the root region of the plant and the imbalance in the nutrient intake of the plant as a result of the increase in osmotic pressure. Knowing the degree of tolerance to salinity in the germination and early development stages of plants is an important parameter in terms of evaluating the growth and development of the plant. Many researchers have reported that salinity slows down root and shoot growth in plants and negatively affects germination (Vicente et al. 2004; Abdul Jaleel et al. 2007; Demir Kaya et al. 2012; Moghaddam et al. 2018; Büyükyıldız et al. 2023).

Table 2. Fresh seedling weight and germination rate values of flax seeds at different salt concentrations

Fresh seedling weight (mg)				
Dose /Variety	**Somme**	**Midin**	**Norman**	**Average**
Control	0.700^{a}	0.636^{b}	0.6333^{b}	0.656^{A}
50 mM	0.693^{a}	0.600^{b}	0.540^{c}	0.611^{B}
100 mM	0.410^{d}	0.303^{e}	0.263^{e}	0.325^{C}
200 mM	0.263^{e}	0.143^{f}	0.255^{g}	0.135^{D}
Average	0.516^{x}	0.359^{z}	0.420^{y}	
CV (%)	6.26			
$LSD_{(0.05)}$	V: 0.036*	D: 0.026*	V × D: 0.046*	
Standard Error	V: 0.007	D:0.009	V × D: 0.015	
Germination rate (%)				
Dose / Variety	**Somme**	**Midin**	**Norman**	**Average**
Control	92.88^{a}	92.55^{a}	91.22^{a}	92.21^{A}
50 mM	75.78^{ab}	52.33^{d}	67.77^{bc}	65.29^{B}
100 mM	60.00^{c}	28.11^{de}	40.00^{d}	43.70^{C}
200 mM	21.11^{ef}	17.77^{f}	4.49^{g}	12.96^{D}
Average	62.44^{x}	47.69^{y}	50.87^{y}	
CV (%)	14.80			
$LSD_{(0.05)}$	V: 9.02*	D: 8.78*	V × D :15.22**	
Standard Error	V: 2.131	D: 2.461	V × D: 4.263	

* and **:significant at $P \leq 0.05$ and $P \leq 0.01$ respectively. N.S: No significant. a, b, c...; varieties × doses, A, B...; average of doses, x, y, z... ; average of varieties

CONCLUSION

The purpose of evaluating plants in terms of salt resistance is to get an idea of which plants can and cannot be grown in salty soils. Salinity studies are carried out not only among plants but also between different varieties or genotypes of a plant. The effect of salt stress on cultivars was found to be significant in the study using three different flax seeds and four different salinity doses, including a control. It was observed that all properties examined in the study were adversely affected by high salt concentrations. It was determined that there were serious differences between the highest salt dose of 200 mM and the control group in which only pure water was used. In the study, the 'Somme' variety gave better (positive) results than other varieties in terms of germination parameters and seedling growth at high salinity doses. It was determined that the 200 mM salt dose significantly affected the germination of flax.

CONFLICT OF INTEREST

The authors declared no conflict of interest.

AUTHOR CONTRIBUTION

All authors contributed equally.

ETHICAL APPROVAL

During the writing process of the study titled "**Investigation of Germination and Early Seedling Development of Some Flax (*Linum usitatissimum* L.) Seeds Under Salt Stress**", scientific rules, ethical and

citation rules were followed; No falsification has been made on the collected data and this study has not been sent to any other academic media for evaluation. Ethics committee approval is not required.

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Research Article

Bazı Ceviz Çeşitlerinde Meyve ve Kimyasal Özelliklerin Ekolojilere Göre Değişimi

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ÖZET

Ceviz (*Juglans regia* L.), dünyada en çok üretilen ve tüketilen sert kabuklu meyve türlerinden biridir. Önemli miktarlarda protein, yağ ve yağ asiti içeriği tüketimini artırmaktadır. Verim, meyvenin fiziksel ve kimyasal özellikleri çeşidin genetik yapısına bağlı olmakla birlikle çevre koşullarından da önemli ölçüde etkilenmektedir. Bu araştırmada 5 ceviz çeşidinde meyve özelliklerinin ekolojilere göre değişimi saptanmıştır. Ortalama meyve ağırlığı en yüksek 77H1 genotipinden (15.84 g), en düşük Tokat 1 çeşidinden (8.78 g) elde edilmiştir. Kabuklu meyve özellikleri ekolojilere göre değişim göstermiş olup, Hatay ve Yalova illerinde en yüksek meyve ağırlığı 77H1 genotipinden (17.89 g; 16.83 g), Kahramanmaraş ilinde ise KR2 (17.60 g) ve Şen 1 (16.67 g) çeşitlerinden elde edilmiştir. Kabuklu ve iç ceviz ağırlığı (14.31 g ve 7.20 g), iç oranı (%51.18), meyve eni, boyu ve yükseklik değerleri Hatay ilinde yüksek bulunurken, bu ilde iç ceviz renklerinin daha koyu olduğu belirlenmiştir. Yağ oranı Kahramanmaraş ve Yalova illerinde (%60.72 ve %61.77) yüksek olurken, ceviz çeşitlerinin protein içeriği Hatay ve Yalova illerinde (%18.33 ve %16.79) yüksek bulunmuştur. Palmitik, Stearik ve Limolenik yağ asitleri Kahramanmaraş ilinde yüksek olurken, Yalova ilinde Linoleik, Hatay ilinde ise Oleic asit oranı yüksek olmuştur.

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Variation of Fruit and Chemical Properties According to Ecology in Some Walnut Cultivars

ABSTRACT

Walnut (Juglans regia L.) is one of the most produced and consumed hard-shelled fruit species in the world. Significant amounts of protein, fat and fatty acid content increase its consumption. Yield, physical and chemical properties of the fruit depend on the genetic structure of the variety and are also significantly affected by environmental conditions. In this study, it was determined that the fruit and chemical content of 5 walnut cultivars grown in different ecologies changed according to different ecologies. The aveage fruit weight showed the genetic characteristics of the cultivars, the highest fruit weight was added from the 77H1 gemotype (15.84 g) and the lowest from the Tokat 1 cultivar (8.78 g). Fruit characteristics also changed according to ecology, the highest fruit weight was obtained from 77H1 genotype (17.89g; 16.83 g) in Hatay and Yalova provinces, and from KR2 (17.60 g) and Şen 1 (16.67 g) varieties in Kahramanmaraş. While the weight of shelled fruit and kernel (14.31 g and 7.20 g), kernel ratio (51.18%), nut width, length and height values were higher in Hatay, it was determined that the color of kernels was darker in Hatay province. Fat content was high in Kahramamaras and Yalova (60.72% and 61.77%), protein content was high in Hatay and Yalova (18.33% and 16.79%). While Palmitic, Stearic and Limolenic fatty acids were high in Kahramanmaraş, Linoleic acid was high in Yalova and Oleic acid was high in Hatay.

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GİRİŞ

Ceviz, *Juglandales* takımının *Juglandacea* familyasının *Juglans* cinsine girmektedir. *Juglans* cinsi içerisinde yer alan 21 ceviz türü bilinmektedir. Bu türler içerisinde ekonomik getirisi ve besin değeri yüksek olan *Juglans regia* L. dır. Bu tür Anadolu cevizi, İran cevizi ve İngiliz cevizi olarak da tanınmakta ve Anadolu, İran, Himalaya ve Güney Doğu Avrupa'da doğal olarak yetişmektedir (Şen 1986).

Ceviz besin içeriği açısından zengin bir meyve türüdür. Özellikle doymamış yağ asitleri ile öne çıkmaktadır (Ros ve ark. 2004). Sağlık bakımından olumlu etkisi nedeniyle ceviz tüketimi önerilmektedir (Poulose ve ark., 2014). Özellikle meme, prostat, kolon gibi farklı kanser türlerine karşı etkili bir besin olduğu da bilinmektedir (Hardman, 2014; Guan ve ark. 2018). Bu durum, cevizin eşsiz bileşiminden kaynaklanmaktadır. Cevizin ana besin maddeleri proteinler, karbonhidratlar, diyet lifi, mineraller ve büyük ölçüde yağdan oluşmaktadır. Ayrıca, hidrolize olabilen tanenler (gallotaninler ve ellagitanninler), A ve C vitaminleri, E vitamini ve diğer tokoferoller, aminoasitler vb. gibi bazı biyoaktif bileşikler açısından da zengindir (Bueno ve ark. 2021). Cevizin en önemli özelliğinden biri de yağ bileşimidir. Ceviz, yağ içeriği yüksek diğer türlerin çoğuyla karşılaştırıldığında, doymuş yağ asitlerinin (SFA) toplam yağ asitlerine oranının düşük olduğu görülmektedir. Ayrıca ceviz, daha düşük oranda tekli doymamış yağ asitlerine (MUFA) sahiptir. Çoklu doymamış yağ asitlerinin (PUFA) fazla olması, özellikle linoleik ve α-linolenik asit konsantrasyonlarının yüksek olması nedeniyle ω3:ω6 oranı yüksektir (Pereira ve ark, 2008; Hayes ve ark, 2016). Zengin besin içeriğine ilave olarak öteki meyve türlerine kıyasla yetiştiriciliğinin, özellikle hasat ve meyvelerinin muhafazasının kolay olması cevizin üretimini artırmaktadır. Birim alandan getirisinin yüksek olması da ceviz yetiştiriciliğinin artmasındaki en önemli nedenler arasındadır.

Cevizin anavatanları içerisinde yer alan Türkiye'de, 2020 yılında 286.706 ton ceviz üretimi gerçekleştirilmiştir. Türkiye bu üretim değeri ile Çin Halk Cumhuriyeti, Amerika Birleşik Devletleri ve İran'dan sonra 4. sırada yer almakta ve dünya üretiminin % 6,4 ünü sağlamaktadır (Anonim 2022). Bu üretim yıldan yıla da artış göstermektedir.

Farklı iklim koşularına uyum ceviz çeşitlerine göre değişmektedir. 400 ila 1800 saat arasında soğuklama gereksinimi olan cevizin deniz seviyesinden 1700 m yüksekliğe kadar yetiştiriciliği yapılabilmektedir (Akça, 2001; Sütyemez ve ark. 2021). Nitekim, Bayazıt ve ark. (2020) Akdeniz bölgesi sahil şeridinde de ceviz yetiştirildiğini, ancak düşük yükseltilerde yüksek yaz sıcaklıklarına bağlı olarak meyvenin yeşil kabuklarında yanma ve iç cevizlerde kararmaların oluştuğunu bildirmektedir. Benzer şekilde Miletic ve ark. (2009) meyve ağaçlarında verim ve meyve kalitesi üzerine kültürel uygulamaların etki etmesine karşılık, ana etkinin ekolojik koşullar olduğunu belirtmektedir. Meyve kalitesine ekolojinin etkisi bilinmektedir**.** Nitekim sert kabuklu meyve türlerinde meyvenin fiziksel ve kimyasal özellikleri üzerine ekolojinin etkisinin araştırıldığı birçok araştırma bulunmaktadır (Parcerisa ve ark. 1995; Ağar ve ark.1995; Balcı 2002). Sıcaklık ise ceviz meyve kalitesini etkileyen en önemli ekolojik faktör olarak belirtilmektedir (Şen 1986; Akça 2001). Stoickov (1967) düşük sıcaklık ve serin rüzgarların cevizde meyvenin fiziksel ve kimyasal özelliklerine ve morfolojik gelişimine olumsuz etki ettiğini bildirmektedir. Balcı (2002) cevizde rakımın meyve kalitesini etkilediğini, yükseklik arttıkça meyve kalitesinin düştüğünü bildirmiştir.

Artan ceviz üretiminin devam etmesi, ekolojik koşullara uygun ceviz çeşitlerinin belirlenmesi ve önerilmesine bağlıdır. Bu araştırmanın amacını da 77H1, KR2, Şebin, Şen 1 ve Tokat 1 ceviz çeşitlerinin Hatay, Kahramanmaraş ve Yalova ekolojilerindeki fiziksel ve kimyasal özelliklerinin belirlenmesi oluşturmuştur.

MATERYAL ve METOD

Denemede materyal olarak farklı yükseklik ve iklim özelliklerine sahip Hatay, Kahramanmaraş ve Yalova (Tablo 1) olmak üzere 3 farklı ekolojide yer alan 77H1, KR2, Şebin, Şen 1 ve Tokat 1 ceviz çeşitleri kullanılmıştır. Ceviz çeşitleri kendi çöğürleri üzerine aşılı olup tam verim yaşındadır. Araştırmada kullanılan ağaçlara sulama, hastalık ve zararlılarla mücadele, gübreleme gibi kültürel uygulamalar rutin olarak gerçekleştirilmiştir.

Tablo 1. *Deneme alanlarının iklim verileri*

İklim Parametreleri	Yayladağı/Hatay	Kahramanmaraş	Yalova
Rakım	421	930	5
Koordinat	35°55′K, 36°05′D	37°35'27"K 37°03'28"D	40°39'43"K 29°17'55"D
Ortalama Sıcaklık (°C)	7.6-26.8	4.9-28.5	6.5-23.7
Ortalama En Yüksek Sıcaklık (°C)	11.1-36.8	8.3-36.1	9.9-28.4
Ortalama En Düşük Sıcaklık (°C)	4.2-22.3	1.3-21.9	3.2-18.2
En Yüksek Sıcaklık (°C)	20.5-43.9	47.5	25.0-45.4
En Düşük Sıcaklık (°C)	-14.6-15.9	-24.9	-9.6-10.0
Yağış (mm)	1103	387.2	749.9

Meyve özelliklerinin belirlenmesinde 3 yinelemeli ve her yinelemede 10 adet meyve olacak şekilde toplam 30 meyve kullanılmıştır. Ceviz çeşitlerine ait meyvelerde ortalama kabuklu ceviz ağırlığı **(**g), eni (mm), boyu (mm) ve yüksekliği (mm), kabuk kalınlığı (mm), iç ceviz ağırlığı (g) ve randıman (%) ölçümleri Bayazıt'a (2000) göre gerçekleştirilmiştir.

Denemede kullanılan ceviz genotiplerinin meyvelerindeki renk ölçümleri Renk ölçer yardımıyla (Minolta CR-300 Chromometer) gerçekleştirilmiş L*, a, b, C, h cinsinden ifade edilmiştir. Renk değerlerinde, 'L' rengin parlaklığındaki değişimi (L; 0 siyah, 100 beyaz), 'a' yeşilden kırmızıya renk değişimini ('+' değerler kırmızı, '-' değerler yeşil), 'b' sarıdan maviye renk değişimini ('+' değerler sarı, '-' değerler mavi), 'C' rengin yoğunluğunu ve 'h^o' rengin açı değerini (0; kırmızı-90^o; sarı, 180^o; mavimsi-yeşil, 270^o; mavi) göstermektedir (Zerbini ve Polesollo, 1984).

Yağ oranı (%) Soxholet cihazında Akyüz ve Kaya (1992)'ya göre saptanmıştır. Yağ tayininden sonra ceviz çeşitlerinde yağ asidi kompozisyonunu belirlemek amacıyla esterleştirme işlemi yapılmış (IUPAC 1989) ve yağ asitleri gaz kromatografisi ile saptanmıştır. Yağ asitleri analizleri, Hewlett Packard 6890N gaz kromatografisi (Agilent, ABD) ile alev iyonizasyon dedektörü (FID) ve Spelco 2380 (60m x 20 µm; 0.2 µm) kapiler kolon (Supelco, Bellefonte, PA, ABD) kullanılarak yapılmıştır. Analiz aşamasında çıkan pikler, standarttan yararlanarak pikin zaman ve alan hesaplaması ile kompozisyonları belirlenmiş ve sonuçlar % yağ asidi olarak verilmiştir. Protein oranı (%) ise Kjeldahl metoduna göre (Kacar, 1984) azot tayini yapılmış ve belirlenen azot miktarı 6,25 ile çarpılarak protein oranları hesaplanmıştır.

BULGULAR ve TARTIŞMA

Ceviz çeşitlerinin farklı illerdeki meyve özellikleri Tablo 2'de verilmiştir. Tabloden de görülebileceği gibi kabuklu ve iç ceviz ağırlıkları, iç ceviz oranı, meyve boyutları beklenildiği gibi çeşitlere göre değişmekle birlikte illere göre de değişmiştir. Hatay ve Yalova illerinde en yüksek kabuklu ceviz ağırlığı 77H1 genotipinden (17.89 g; ve 16.03 g) elde edilirken, Kahramanmaraş ilinde KR2 ve Şen 1 (17.60 g ve 16.67 g) çeşitlerinden elde edilmiştir. Denemenin yürütüldüğü 3 ilde de en düşük kabuklu ceviz ağırlığı Tokat 1 çeşidinden elde edilmiş, bu çeşidin ortalama kabuklu meyve ağırlığı 3 farklı ekolojik koşulda da 10 gramın altında gerçekleşmiştir.
İç ceviz ağırlıkları da çeşitlere göre değişmiş, Hatay ve Kahramanmaraş ilinde en yüksek değer (8.78 g ve 8.34 g) Şen 1 çeşidinden elde edilirken, Yalova ilinde en yüksek iç ceviz ağırlığı 7.33 g ile KR2 çeşidinden elde ediliştir. İç ceviz oranı beklenildiği şekilde çeşitlere göre değişmekle birlikte ekolojilere göre de farklılık göstermiştir. Nitekim, Tokat 1 çeşidi Hatay ilinde %61.37'lık iç oranı ile öteki çeşitlere kıyasla en yüksek iç oranına sahip olurken, Tokat 1 çeşidi için bu değer Kahramanmaraş ilinde %52.25, Yalova ilinde de %53.24 olarak gerçekleşmiştir. Meyve boyutları çeşitlere göre değiştiği gibi, yetiştirildikleri ekolojilere göre de değişmiştir (Tablo 2).

Denemenin yürütüldüğü üç il ortalaması olarak ceviz çeşitleri değerlendirildiğinde çeşitlerin genetik özelliklerini sergiledikleri görülmektedir. Beklenildiği şekilde kabuklu ceviz ağırlığı açısından 3 il ortalaması en yüksek çeşit 15.84 g ile 77H1, 15.33 g ile KR2 ve 15.08 g ile Şen 1 çeşitleri olurken, kabuklu ceviz ağırlığı ortalaması en düşük çeşit 8.78 g ile Tokat 1 olmuştur. Kabuklu meyve boyutlarının kabuklu meyve ağırlığına paralel gerçekleştiği de görülmüştür. 3 ilin iç ceviz ağırlığı ortalaması en düşük Tokat 1 çeşidinde

(4.90 g) olurken, en yüksek Şen 1 çeşidinde (7.60 g) olmuş, KR2 çeşidinde de iç ceviz ağırlığının yüksekliği dikkat çekmiştir. Tokat 1 çeşidinde iç oranı ortalaması öteki çeşitlere kıyasla yüksek (%55.62) olurken, 77H1 genotipinde iç oranının düşük olduğu (%42.03) görülmüştür. Sert kabuklu meyve türlerinde kabuğun ince ve yeterinde de dayanıklı olması istenilmektedir. Gerçekleştirilen ölçümler sonucunda kabuk kalınlıkları ortalaması çeşitlere göre değişmiştir. 77H1 çeşidinde kabuk kalınlığı yüksek olurken (1.74 mm), Tokat 1 çeşidinde düşük (1.43 mm) gerçekleşmiştir. Denemede yer alan öteki ceviz çeşitlerinin 3 il için kabuk kalınlığı ortalaması verilen değerler arasında dağılım göstermiştir.

Ekolojik koşullar ceviz çeşitlerinin meyve özellikleri üzerine etkili olmuş, meyve özelliklerine ilişkin en yüksek değerler Akdeniz iklim koşullarına sahip Hatay ilinden elde edilmiştir. Ortalama meyve ağırlığı Hatay ilinde 14.31 g olurken, bu değer Ilıman iklim koşullarına sahip Kahramanmaraş'ta 12.72 g ve Yalova'da 12.15 g olarak belirlenmiştir. İç ceviz ağırlığı ortalamaları istatistiki olarak önemli olmuş, Hatay ilinde 7.20 g, Kahramanmaraş ilinde 6.43 g ve Yalova ilinde 5.78 g olarak elde edilmiştir. İç ceviz oranı Hatay ilinde %50.54 olurken, Kahramanmaraş ve Yalova illerinde yakın olmuş ve sırasıyla %48.20 ve %48.41 olarak gerçekleşmiştir.

Ortalama meyve ağırlığında olduğu şekilde meyve eni, boyu ve yüksekliği değerleri de Hatay ilinde daha yüksek olmuştur. Buna karşılık Kahramanmaraş ve Yalova illerinde meyve boyutlarına ilişkin değerlerin ortalamaları arasındaki farklılıklar istatistiki olarak önemsiz olmuş, değerler çok yakın elde edilmiştir. Değerler yakın olmakla birlikte Yalova ilinde kabuk kalınlıkları öteki illere kıyasla ince olmuştur.

Tokat 1 ceviz çeşidinde kabuklu ceviz ağılığının düşük olduğu, bu çeşidin denemenin yürütüldüğü 3 ilde de ticari bir ceviz çeşidinin minimum ağırlığı olan 10 g'ın (Çelebioğlu, 1985) altında kaldığı görülmektedir. Denemede yer alan ceviz çeşitlerinden elde edilen meyve özelliklerinin öteki araştırmaların sonuçları ile yakın olduğu görülmektedir. Tosun ve Akçay (2005) Yalova ekolojik koşullarında kabuklu ve iç ceviz ağırlıklarını 77H1 çeşidi için 19.70 g ve 9.10 g; Şebin çeşidi için 12.20 g ve 6.05 g, Tokat 1 çeşidi için 9.95 g ve 5.11 g ve Şen 1 çeşidi için de 10.40 g ve 5.37 g olarak bildirmiştir.

Bakkalbaşı ve ark. (2010) Yalova Atatürk Merkez Araştırma Enstitüsünden 2004 yılında temin ettikleri Şebin ve Şen 1 çeşitlerinde ortalama meyve ağırlığını 8.98 g, ve 17.28 g olarak bildirmişlerdir. İç ceviz ağırlığı ve randıman Şebin çeşidinde 5.40 g ve %59.54, ve Şen 1 çeşidinde de 7.79 g ve %44.90 olarak belirtilmiştir.

Bilgin ve ark. (2018) bazı ceviz çeşitlerinin Menemen ekolojik koşullarında meyve özelliklerini saptadıkları araştırma sonucunda Şen 1 ve Şebin çeşitlerinde ortalama meyve ağırlığının 16.62 g ve 10.42 g, iç ağırlığının 7.25 ve 3.65 g, iç oranının %43.70 ve %35 olduğunu bildirmişlerdir. Kabuk kalınlıklarını 1.42 mm ve 1.36 mm olarak belirten araştırıcılar meyve eni, boyu ve yüksekliği değerlerini de 39.39 mm ve 34.61 mm, 39.93 mm ve 37.66 mm, 42.09 mm ve 32.44 mm olarak belirtmişlerdir.

Kültürel işlemlerin olduğu kadar ekolojinin de meyve kalitesi üzerine etkisinin olduğu bilinmektedir. Özellikle yükseltinin gerek fiziksel, gerekse kimyasal özellikler üzerine etili olduğu da bildirilmektedir. Koyuncu ve ark. (2004) 300 ve 1200 m yükseklikerde kabuklu ceviz ağırlıklarını ceviz çeşitlerine göre değiştiğini, düşük rakımdan elde edilen kabuklu ceviz ağırlıklarının daha yüksek olduğunu bildirmişlerdir. Gerçekleştirmiş olduğumuz araştırmada düşük rakımlı Hatay ilinden elde edilen verilerin yüksekliği verilen araştırma sonucu ile uyumlu görülmektedir. Buna karşılık daha düşük rakımda yer alan Yalova'dan elde edilen sonuçların düşüklüğü dikkat çekmiştir. Yalova ilimim deniz seviyesinde olmasına karşılık Hatay ve Kahramanmaraş illerine göre daha kuzey enlemlerinde yer alması ve ılıman iklime sahip olması dikkate alınmalıdır.

Tablo 2. *Bazı çeviz çeşitlerinin farklı illerdeki meyve kalite özellikleri*

Hatay (H)	Kabuklu ceviz				Kabuk Kalınlığı (mm)	İç Ceviz Ağırlığı (g)	Randıman (%)
	Ağırlığı (g)	Eni (mm)	Boyu (mm)	Yüksekliği (mm)			
77H1	17.89 a	36.03 b	48.29 a	40.39 a	1.76 a	7.59 b	42.49 g
KR2	15.01 bc	36.32 b	43.89 sb	38.55 b	1.47 b	7.22 bc	47.41 c
Şebin	13.32 c	32.41 c	40.16 b	34.02 c	1.72 a	6.64 c	50.28 bc
Şen1	16.17ab	37.25 a	38.15 bc	40.37 a	1.49 b	8.78 a	54.33 b
Tokat 1	9.49 d	28.07 d	34.32 c	31.37 d	1.39 b	5.81 d	61.37 a
	1.87	0.87	6.50	0.78	0.13	0.80	4.83
Kahramanmaraş (K)							
77H1	13.61 b	33.94 c	45.86 a	36.33 b	1.75 b	5.70 c	42.49 c
KR2	17.60 a	38.47 a	40.28 n	40.28 a	1.85 a	7.52 b	42.76 c
Şebin	9.64 c	32.00 d	36.34 d	31.20 c	1.25 d	5.95 c	62.01 a
Şen1	16.67 a	36.11 b	38.84 c	39.45 a	1.53 c	8.34 a	50.16 b
Tokat 1	8.87 c	26.94 e	34.63 e	30.41 c	1.53 c	4.63 d	52.25 b
	1.46	0.85	0.74	0.92	0.08	0.58	2.54
Yalova (Y)							
77H1	16.03 a	34.75 b	44.93 b	37.91 a	1.73 a	6.60 b	41.108 b
KR2	13.54 b	37.56 a	50.03 a	38.34 a	1.64 ab	7.33 a	54.72 a
Şebin	10.81 c	30.75 c	38.59 d	31.60 c	1.53 b	5.02 d	46.24 a
Şen1	12.40 b	34.08 b	41.10 c	34.89 b	1.58 b	5.66 c	45.83 b
Tokat 1	7.99 d	26.47 d	34.16 e	29.55 d	1.37 c	4.25 e	53.24 a
	1.54	1.06	1.91	1.42	0.12	0.48	6.08
İller ortalama							
Hatay	14.31 a	34.66 a	40.96 ab	36.94 a	1.56 a	7.20 a	51.18 a
K.Maraş	13.28 ab	33.49 a	39.19 b	35.53 b	1.58 a	6.43 b	49.94 a
Yalova	12.15 b	32.72 b	41.76 a	34.46 c	1.57 a	5.78 c	48.22 a
	1.18	0.68	2.03	0.97	0.10	0.52	3.82
Çeşit ortalama							
77H1	15.84 a	34.91 c	46.36 a	38.21 a	1.74 a	6.63 b	42.03 c
KR2	15.33 a	37.45 a	44.73 a	39.06 a	1.65 ab	7.36 a	48.30 b
Şebin	11.25 b	31.72 d	38.36 b	32.27 b	1.50 c	5.87 c	52.84 ab
Şen1	15.08 a	35.81 b	39.36 b	38.23 a	1.54 bc	7.59 a	50.10 b
Tokat 1	8.78 c	27.16 e	34.37 c	30.44 c	1.43 c	4.90 d	55.62 a
	1.52	0.89	2.63	1.26	0.13	0.66	4.94

Renk ceviz için önemli kalite kriterlerindendir ve iç ceviz renginin açık olması istenilmektedir. Yüksek yaz sıcaklıklarının iç cevizde kararmalara neden olması nedeniyle yüksek yaz sıcaklıkları ceviz yetiştiriciliği için belirleyici olmaktadır. Nitekim, Şen (2011), 35ºC ve üzeri sıcaklıkların iç cevizlerde kararmalara neden olduğunu bildirmektedir.

Denemede yer alan ceviz çeşitlerinde iç ceviz renk değerleri ceviz çeşitlerine ve illere göre değişmiştir**.** Cevizde iç rengin açıklığının göstergesi olan L, b ve h değerlerinin yüksek olmasıdır. Bu açıdan denemede yer alan ceviz çeşitleri iller bazında değerlendirildiğinde Hatay ilinde en yüksek L (41.88), b (24.67) ve h (68.58) değerleri KR2 genotipinden elde edilmiştir. Yine Şebin çeşidinde de Hatay ili ekolojik koşullarında iç cevizlerin açık olduğu görülmüştür. Buna karşılık Tokat 1 ceviz çeşidinde iç ceviz (L, b ve h değerleri sırasıyla; 29.51, 19.13, 55.69) öteki çeşitlere kıyasla daha koyu renge sahip olmuştur. Buna karşılık Kahramanmaraş ilinde Tokat 1 çeşidinde iç ceviz rengi (L, b ve h değerleri sırasıyla; 48.35, 31.28, 72.08) öteki çeşitlerden daha açık olmuştur. Yalova ilinde ise en açık iç cevizler 77H1 çeşidinden (L, b ve h değerleri sırasıyla; 44.17, 35.30, 73. 58) elde edilirken, Şebin ve Şen 1 çeşitlerinin de iç cevizlerinin açık renkte oldukları belirlenmiştir.

Denemenin yürütüldüğü 3 ilin ortalaması olarak ceviz çeşitleri değerlendirildiğinde 77H1 genotipinde (L, b ve h değerleri sırasıyla; 39.83, 30.94. 69.69) iç rengin öteki çeşitlere kıyasla daha açık olduğu görülmektedir. Denemede yer alan çeşitler içerisinde en koyu içe sahip olan çeşit ise Tokat 1 (L, b ve h değerleri sırasıyla; 37.87, 24.87. 64.25) olmuştur.

Ekolojinin bitki tür ve çeşitleri üzerine olan etkisi gerçekleştirilen bu araştırmada net bir şekilde görülmüştür. Yüksek yaz sıcaklılarının iç cevizlerde kararmaya neden olduğu değişik araştırıcılar tarafından ortaya konulmuştur. Araştırmanın yürütüldüğü Hatay ili Türkiye'nin en güneyinde yer almakta ve Subtropik iklime sahip olması nedeniyle de yaz aylarında sıcaklıklar çok yüksek seyretmektedir. Bunun sonucu olarak ta

yetiştiricilik 700 m ve altı yükseltilerde yapılıyorsa iç ceviz renklerinde koyulaşmalar meydana gelmektedir. Nitekim, gerçekleştirilen renk ölçümleri sonucunda öteki illere kıyasla Hatay ilinde iç ceviz renklerinin koyu olduğu net bir şekilde görülmektedir. L, b ve h değerleri Hatay ilinde sırasıyla 33.90, 23.38 ve 63.14 olarak elde edilirken, bu değeler, Yalova ilinde 38.89, 28.86 ve 68.58 olarak elde edilmiştir. Deniz seviyesinde olmasına rağmen, ülkenin kuzeyinde yer alması nedeniyle ılıman özellik göstermesi Yalova ilinde de iç ceviz renklerinin daha açık olmasının nedeni olarak değerlendirilmiştir. Benzer şekilde deneme bahçesinin deniz seviyesinden 1100 m yükseklikte bulunduğu Kahramanmaraş ilinde de iç cevizler denemin yürütüldüğü öteki illere kıyasla daha açık renkli olmuştur. L, b ve h değerleri Kahramanmaraş ilinde 42.15, 27.85 ve 69.22 olarak gerçekleşmiştir.

Renk ölçüm sonuçları önceki araştırmaların sonuçlar ile uyumlu olmuştur. Tefek (2016) Kaolin uygulamasının bazı ceviz çeşitlerinde verim ve kaliteye etkisini belirlemek için Hatay ili Yayladağı ilçesinde gerçekleştirdiği araştırma soncunda yüksek yaz sıcaklıklarının iç cevizlerde kararmalara neden olduğunu, kaolin uygulamasının meyve yüzey sıcaklığını düşürmesi nedeniyle iç cevizlerin kaolin uygulanmayanlara göre daha açık olduklarını belirtmiştir.

Hatay Yayladağı ekolojisinde gerçekleştirilen bir araştırmada iç ceviz renkleri ölçümüş, en yüksek L* değeri 'Şebin' (41.6) çeşidinden, en yüksek a* değeri Kaplan 86 çeşidinden (10.97) ve yine en yüksek C ve h^o değerleri '77H1' (31.0 ve 29.0) çeşitlerinden elde edilmiştir (Bayazıt ve Sümbül, 2012). Bu araştırmadan elde edilen değerler araştırıcıların değerleri ile paralellik göstermektedir. Denemelerin aynı ilde gerçekleştirilmesine rağmen görülen farklılıklar ise deneme yıllarının farklı olması nedeniyle iklim verilerinin farklı olmasıdır.

Tablo 3. *Bazı ceviz çeşitlerinin farklı illerdeki iç ceviz renk değerleri*

Hatay (H)	**İç Ceviz Rengi**				
	L	**a**	***b***	***C***	***h°***
77H1	32.18 c	12.53a	28.42 a	31.37 a	65.67 ab
KR2	41.88 a	8.14 b	24.67 ab	26.34 ab	68.58 a
Şebin	39.75 ab	11.16 a	26.97 a	29.27 a	67.39 a
Şen1	26.23 c	10.57 a	21.34 bc	22.64 b	58.38 bc
Tokat 1	29.51 c	11.03 a	17.13 c	20.53 b	55.69 c
	9.39	2.10	6.36	5.93	7.97
Kahramanmaraş(K)					
77H1	43.13 b	8.09 b	29.10 a	29.60 ab	69.82 a
KR2	39.16 bc	7.84 b	24.26 c	25.63 c	71.68 a
Şebin	37.92 c	10.46 a	25.99 bc	26.70 ab	63.71 a
Şen1	42.20 bc	8.60 b	28.62 ab	29.93 ab	68.79 a
Tokat 1	48.35 a	8.60 b	31.28 a	31.49 a	72.08 a
	4.83	1.15	3.08	3.68	10.01
Yalova (Y)					
77H1	44.17 a	10.57 a	35.30 a	36.97 a	73.58 a
KR2	38.58 ab	6.95 b	22.00 c	23.32 c	67.84 ab
Şebin	40.66 ab	10.27 a	30.06 ab	32.26 ab	68.88 ab
Şen1	35.27 b	11.79 a	30.73 ab	33.14 ab	67.63 ab
Tokat 1	35.76 b	11.63 a	26.20 bc	29.09 bc	64.97 b
	5.99	1.69	5.91	5.72	6.33
İller ortalama					
Hatay	33.90 b	10.69 a	23.38 b	26.03 b	63.14 b
K. Maraş	42.15. a	8.72 b	27.85 a	28.67 ab	69.22 a
Yalova	38.89 a	10.24 a	28.86 a	30.94 a	68.58 a
	4.08	0.92	3.03	2.92	3.87
Çeşit ortalama					
77H1	39.83 ab	10.40 a	30.94 a	32.65 a	69.69 a
KR2	39.85 a	7.64 b	23.64 c	25.10 c	69.36 a
Şebin	39.44 ab	10.63 a	27.67 ab	29.41 ab	66.66 ab
Şen1	34.57 b	10.32 a	26.89 bc	28.57 bc	64.93 ab
Tokat 1	37.87 ab	10.42 a	24.87 bc	27.01 bc	64.25 c
	5.26	1.16	5.92	3.76	5.00

Denemede yer alan ceviz çeşitlerinde protein, yağ ve yağ asitleri çeşitlere ve illere göre değişmiş, ortalamaları arasındaki farklılıklar istatistik olarak da önemli olmuştur. En düşük protein oranı Hatay ilinde Şen 1 (%16.56), Kahramanmaraş ilinde KR2 (%12.20), Yalova ilinde de Tokat 1 (%14.45) çeşidinden elde

edilmiştir. En yüksek protein oranları ise Hatay ilinde %19.86 ile Şebin, Kahramanmaraş ilinde %17.70 ile Şebin ve Yalova ilinde de %21.13 ile Şen 1 çeşitlerinden elde edilmiştir.

Denemenin yürütüldüğü tüm illerin ortalaması değerlendirildiğinde KR2 ve Tokat 1 çeşitlerinde protein oranı (%14.97) düşük olurken, bu değer Şebin çeşidinde (%18.76) en yüksek olmuştur. Tüm çeşitlerin ortalama protein oranı Hatay (%18.33) ve Yalova'da (%16.79) yüksek, Kahramanmaraş ilinde (%14.21) bu iki ile kıyasla düşük gerçeklemiştir.

Cevizi önemli kılan en önemli bileşenlerden biri içermiş olduğu yağdır. Ceviz yağının %72 çoklu doymamış yağ asidi (%59 linoleik, %13 linolenik), %18 tekli doymamış yağ asidi (oleik asit) ve %10 doymuş yağ asidi (palmitik, stearik) içerdiği bildirilmektedir (Lavendrine ve ark. 1999; Bayazıt ve Sümbül 2012; Aryapak ve Ziarati 2014).

Gıda değeri, depolama ve sağlıklı yaşam açısından önemli olan ceviz yağının kalitesine içermiş oldukları yağ asitleri etki etmekte ve gerek toplam protein ve yağ içeriği, gerekse yağ asitleri kompozisyonu çeşitlere ve çeşitlerin yetiştirildikleri ekolojik koşullara göre değişmektedir. Bu durum ekolojiye göre çeşit seçiminin yanında, kalite kayıplarını azaltmak amacıyla da kültürel işlemlerin zamanında ve doğru yapılmasını zorunlu kılmaktadır (Beyhan ve ark., 1995; Özcan ve ark., 2010).

Farklı ekolojik koşullara sahip 3 farklı ilde gerçekleştirilen bu araştırmada da verilen değerlerle uyumlu sonuçlar elde edilmiştir. Hatay ilinde en düşük yağ oranı Şen 1 çeşidinden (%51.23), en yüksek yağ oranı Şebin (%56.52) çeşidinden elde edilmiştir. Hatay'dan elde edilen sonuçların aksine Kahramanmaraş ilinde en düşük değer KR2 ve Tokat 1 çeşitlerinden elde edilirken, 77H1, Bilecik ve Şen 1 çeşitlerinden yüksek değerler elde edilmiştir. Yalova ilinde ise en düşük yağ oranı Şen 1 çeşidinden, en yüksek değer ise Tokat 1 çeşidinden elde edilmiştir.

Denemede yer alan ceviz çeşitlerinin 3 il için ortalama yağ oranları arasındaki farklılıklar istatistiki olarak önemli olmuş, en düşük değer %56.42 ile KR2 çeşidinden, en yüksek yağ oranı ise %61.07 ile 77H1 genotipinden elde edilmiştir.

Yağ oranları illere göre de değişmiş, Kahramanmaraş (%60.72)) ve Yalova (%61.77) ilinden elde edilen yağ oranı Hatay (%53.85) ilinden yüksek olmuştur.
Farklı ceviz çeşitleri kullanılarak farklı ekolojilerde gerçekleştirilen önceki araştırmalarda da yağ ve protein içerikleri belirlenmiştir. Pereira ve ark. (2008) gerçekleştirildikleri çalışmada, ceviz çeşitlerinde toplam yağ içeriklerinin %68.83 (Marbot) ile %72.14 (Franquette), ham protein içeriklerinin %14.38 (Lara) ile %18.03 (Marbot) arasında değiştiğini bildirmişlerdir. Bakkalbaşı ve ark. (2010) yaptıkları çalışmada ceviz çeşitlerinde toplam yağ içeriklerinin yıllara göre değişiklik gösterdiğini, çeşitlerin yağ içeriklerinin % 61.47 (Yalova 1) ile %72.56 (Yalova 4); protein içeriklerinin ise % 12.48 (Bilecik) ile %16.90 (Yalova 1) arasında değiştiğini bildirmişlerdir. Bayazıt ve Sümbül (2012) Hatay Yayladağı ilçesinde gerçekleştirdikleri araştırma sonucunda yağ oranlarının %51.73 (Malatya 1) ile %56.31 (Kaplan 86) arasında değiştiğini, yürütmüş olduğumuz denemede de yer alan ceviz çeşitlerinden Tokat 1, Şen 1, Şebin, KR2 ve 77H1 genotiplerinde toplam yağ oranlarının verilen değerler arasında yer aldığını bildirmişlerdir. Araştırıcılar 3 yıl süreyle gerçekleştirdikleri araştırma sonucunda yağ oranlarının yıllara göre de değişiklik gösterdiğini belirtmişlerdir. Yalçın ve ark., (2021**)** Isparta ekolojik koşullarında gerçekleştirdikleri araştırma neticesinde toplam yağ ve protein oranını Bilecik çeşidi için %59.92 ve %16.67, Şebin çeşidi için %61.99 ve %13.85 olarak bildirmişlerdir.

Gerçekleştirilen bu araştırma sonucunda elde edilen toplam yağ ve protein oranları önceki araştırmaların sonuçları ile yakın olmuştur. Araştırma sonuçları arasındaki farklılıkların bitki yaşı, meyve yükü, uygulanan kültürel işlemlerden kaynaklanabileceği düşünülmektedir. Nitekim, meyvelerde biyokimyasal içerikleri üzerine genetik yapının yanı sıra ağacın yaşı, kültürel uygulamalar, hastalık ve zararlılar, ekolojik koşullar ve bitki üzerindeki meyve sayısının da etkili olduğu bildirilmiştir (Bayazıt ve ark. 2020).

Denemede yer alan ceviz çeşitlerinde temel yağ asitlerinden palmitik, stearik, oleik, linoleic ve linolenik asit oranları belirlenmiş elde edilen sonuçlar Tablo 3'de verilmiştir. Tabloden de görüleceği gibi yağ asitleri oranları denemede yer alan ceviz çeşitlerine ve yetiştikleri illere göre değişiklik göstermiştir.

Palmitik asit Hatay ilinde %5.44 (KR2) ile %7.27 (77H1), Kahramanmaraş ilinde %8.03 (Şen 1) ile %9.86 (77H1) ve 9.70 (Şebin) ve Yalova ilinde de 7.21 (Tokat 1 ve KR2) ile 8.51 (77H1) arasında değişmiştir.

Stearik asit oranı Hatay ilinde KR2 çeşidinde (%3.04) yüksek olurken, tüm çeşitlerden elde edilen değerler istatistiki olarak benzer olmuştur. Kahramanmaraş ilinde Şen 1 çeşidinde (%4.08) ve Yalova ilinde de Şebin, 77H1 ve Tokat 1 (%4.19, 4.09 ve %4.13) çeşitlerinde Stearik asit oranı yüksek olmuştur.

Oleik asit oranı Hatay ve Kahramanmaraş illerinde KR2 (%34.62 ve %29.60) ve Şen 1 (%32.37 ve %28.80) çeşitlerinde yüksek olurken, Yalova ilinde de KR2 (%26.42) çeşidinde yüksek olmuştur.

Linoleik asit oranı Hatay ilinde Tokat 1 (%62.56) çeşidinde yüksek olurken, KR2 (%49.16) çeşidinde düşük olmuştur. Kahramanmaraş ilinde Şebin (%50.16) çeşidinde yüksek, KR2 (%46.02) çeşidinde düşük bulunmuştur. Yalova ilinde en yüksek değer Şen 1 (%59.59) çeşidinden elde edilirken, en düşük değer KR2 (%50.91) çeşidinden elde edilmiştir.

Linolenik asit içeriği ise Hatay ilinde Şebin çeşidinde (%9.29) en yüksek olurken, bu değer en düşük 77H1 çeşidinden (%7.31) elde edilmiştir. Bu ilde Şen 1 (%7.64) çeşidinde de Linolenik asit içeriği düşük olmuştur. Kahramanmaraş ilinde en yüksek değer 77H1 (%13.82) ve Şebin (%13.98) çeşitlerinden elde edilirken, bu oran Şen 1 (%11.33) çeşidinde öteki çeşitlere kıyasla düşük gerçekleşmiştir. Yalova ilinde ise en yüksek diğer Tokat 1 (%14.09) çeşidinden elde edilirken, en düşük değer KR2 (%11.98) çeşidinden elde edilmiştir.

Beklenildiği şekilde denemenin yürütüldüğü illerin farklı ekolojik koşullara sahip olması nedeniyle ceviz çeşitlerinden elde edilen protein, yağ ve yağ asitleri oranları illere ve çeşitlere göre değişmiştir. Bu durum ekolojinin genetik yapı üzerine olan etkisini göstermektedir.

Yağ asitleri çeşitler bazında değerlendirildiğinde ortalamaların farklılık gösterdiği görülmektedir. En düşük ve en yüksek Palmitik asit oranları %7.03 (KR2) ile %8.55 (77H1) arasında değişmiştir. Stearik asit oranı tüm çeşitlerde yakın olmuştur. Oleik asit oranı Şrbin çeşidinde en düşük (%22.07), KR2 çeşidinde (%30.21) em yüksek olmuştur. Linoleik asit oranı KR2 çeşidinde (%48.69) düşük, Şebin (%54.14) ve Tokat 1 (%55.21) çeşitlerinde yüksek olmuştur. Linolenik asit oranı da denemede yer alan ceviz çeşitlerinde yakın olmuştur.

Yağ asitlerinde il ortalamaları da değişmiştir. Doymuş yağ asitlerinden Palmitik ve Stearik asit Kahramanmaraş ilinde (%9.03 ve %3.79) yüksek olmuştur. Belirtilen yağ asitlerinin Yalova ilinde de yüksekliği dikkat çekmiştir. Oleik asit oranı Hatay ilinde (%27.92) yüksek olurken, Kahramanmaraş (%26.17) ve Yalova illerinde (%20.81) düşük olmuştur. Çoklu doymamış yağ asitlerinden Linoleik ve Linolenik asit oranları illere göre değişmiş, en yüksek değerler sırasıyla %54.63 ve %13.14 olarak Yalova ilinden elde edilmiştir. Linoleik asit oranının Hatay ilinde de yüksek olduğu (%54.06) görülürken, Linolenik asit oranı (%8.12) öteki illere göre düşük elde edilmiştir. Bu değerler Kahramanmaraş'ta da %48.24 ve %12.74 olarak gerçekleşmiştir.

Toplam protein ve yağ oranlarında da olduğu şekilde yağ asitlerinin illere göre değişmesinde ekolojnin etkisi görülmektedir. Bununla birlikte yağ analizlerine ilişkin elde edilen sonuçlar cevizde gerçekleştirilmiş önceki araştırmaların sonuçları ile kıyaslandığında elde edilen değerlerin optimum olduğu görülmektedir. Nitekim, Bayazıt ve Sümbül (2012) Hatay ekolojik koşullarında benzer çeşitlerle 3 yıl süreyle gerçekleştirdiği araştırma sonucunda yağ asitleri oranının yıllara ve çeşitlere göre değiştiğini bildirmişlerdir. Araştırıcılar Palmitik asit oranının %6.98 (Malatya 1) ile %8.77 (77H1) arasında değiştiğini, en yüksek oleik asit oranının 65/4 (36.76 %), KR2 (34.03 %) ve Şebin (34.01 %) çeşitlerinden elde edildiğini buna karşılık en düşük değerin ise Tokat 1 ve Malatya 1 çeşitlerinden (%21.09 ve %19.33) elde edildiğini bildirmişlerdir. Linoleik asit oranı %41.55 (65/4) ile %59.89 (Malatya 1) arasında değişmiş, en yüksek Linolenik asit oranı Tokat 1 ve 65/4 genotiplerinden (%11.0 ve %10.10), en düşük değer ise Şebin çeşidinden (%8.44), en yüksek stearik asit oranı Kaplan 86 (4.49 %), 65/4 (%4.11),en düşük stearik asit oranı ise Malatya 1 çeşidinden (3.22%) elde edilmiştir. Bilgin ve ark (2018) Menemen ekolojik koşullarında gerçekleştirdikleri araştırma sonucunda Şen 1 ve Şebin çeşitleri için Palmitik asit oranını %6.59 ve %6.56; Stearik asit oranını %3.44 ve %3.19, Oleik asit oranını %21.70 ve %15.01, Linoleik asit oranını %58.28 ve %61.69 ve Linolenik asit oranını da %9.63 ve %12.69 olarak bildirmişlerdir.

Tablo 4. *Bazı çeviz çeşitlerinin farklı illerdeki kimyasal özellikleri*

Hatay (H)	Palmitik	Stearik	Oleik	Linoleik	Linolenik	Yağ (%)	Protein (%)
77H1	7.27 a	2.76 a	26.45 ac	56.10 ab	7.31 a	52.93 ab	19.26 a
KR2	5.44 b	3.04 a	34.62 a	49.16 b	7.70 a	55.05 ab	17.44 a
Şebin	5.87 b	2.91 a	25.86 bx	56.05 ab	9.29 a	56.52 a	19.86 a
Şen1	6.36 ab	2.98 a	32.37 ab	51.43 b	7.64 a	51.23 b	16.56 a
Tokat 1	5.68 b	2.82 a	20.28 c	62.56 a	8.64 a	53.52 ab	18.52 a
	1.29	0.65	8.50	7.30	2.64	3.99	3.40
Kahramanmaraş (K)							
77H1	9.86 a	3.92 ab	22.71 b	49.68 a	13.82 ab	65.06 ab	15.56 ab
KR2	8.46 c	3.69 ab	29.60 a	46.02 b	12.22 bc	54.84 c	12.20 c
Şebin	9.70 a	3.77 ab	22.36 b	50.16 a	13.98 a	62.06 b	17.70 a
Şen1	8.03 c	4.08 a	28.80 a	47.73 ab	11.33 c	66.63 a	13.65 bc
Tokat 1	9.12 b	3.52 b	27.39 a	47.63 ab	12.33 bc	54.99 c	12.97 c
	0.54	0.47	2.60	3.06	1.64	3.19	2.34
Yalova (Y)							
77H1	8.51 a	4.19 a	22.59 b	50.98 c	13.72 ab	65.21 ab	14.359 c
KR2	7.21 c	3.47 b	26.42 a	50.91 c	11.98 b	59.37 bc	15.273 c
Şebin	8.25 ab	4.09 a	18.00 cd	56.22 b	13.43 ab	61.69 b	18.734 b
Şen1	7.59 bc	3.63 ab	16.92 d	59.59 a	12.33 ab	53.86 c	21.135 a
Tokat 1	7.21 c	4.13 a	20.11 bc	55.45 b	14.93 a	68.75 a	14.453 c
	0.82	0.61	2.87	2.07	1.91	5.93	2.26
İller ortalama							
Hatay	6.13 c	2.90 b	27.92 a	55.06 a	8.12 b	53.85 b	18.33 a
Kahramanmaraş	9.03 a	3.79 a	26.17 a	48.24 b	12.74 a	60.72 a	14.21 b
Yalova	7.76 b	3.90 a	20.81 c	54.63 a	13.11 a	61.77 a	16.79 a
	0.43	0.26	2.89	2.67	0.87	3.59	1.59
Çeşit ortalama							
77H1	8.55 a	3.62 a	23.91 bc	52.25 a	11.61 ab	61.07 a	16.39 bc
KR2	7.03 c	3.40 a	30.21 a	48.69 b	10.63 bc	56.42 b	14.97 c
Şebin	7.94 b	3.59 a	22.07 c	54.14 a	12.23 a	60.09 ab	18.76 a
Şen1	7.33 c	3.56 a	26.03 b	52.92 a	10.43 c	57.24 ab	17.11 ab
Tokat 1	7.33 c	3.49 a	22.59 bc	55.21 a	11.68 ab	59.08 ab	14.97 c
	0.55	0.33	3.72	3.45	1.12	4.52	2.05

SONUÇ

Bu araştırma farklı ekolojilerin bazı ceviz çeşitlerinde meyvenin fiziksel ve kimyasal özelliklerine etkisinin belirlenmesi amacıyla gerçekleştirilmiştir. Gerçekleştirilen bu araştırma sonucunda ceviz çeşitlerinde meyvenin fiziksel özelliklerinin ekolojiden ziyade genetik yapının etkisinde olduğu, çeşit özelliklerini gösterdiği belirlenmiştir. Bununla birlikte, ekolojik koşullarında meyvenin fiziksel ve kimyasal özelliklerine etki ettiği, ortalama meyve ağırlığı, eni, yüksekliği, iç ceviz ağırlığı ve iç ceviz oranının Subtropik iklime sahip Hatay ilinde yüksek olduğu görülmüştür. Denemede yer alan ceviz genotiplerinde iç renk bariz şekilde ekolojiden etkilenmiş, yaz sıcaklıklarını yüksek olduğu Hatay ilinde iç ceviz renkleri koyu olmuştur. Bu denli yaz sıcaklıklarının yüksek olduğu alanlarda iç cevizlerde kararmanın önlenmesi için kaolin gibi güneş ışınlarını yansıtıcı maddelerin kullanılması gerekmektedir. Yağ oranı Kahramanmaraş ve Yalova, protein oranı Hatay ilinde yüksek elde edilmiştir. Yağ asitlerinin de Kahramanmaraş'ta yüksek olduğu görülmüştür. Ceviz meyvelerinin yağ ve protein içeriği beslenme koşullarından etkilenmektedir. Bu nedenle denmede yer alan ceviz çeşitleri için illere göre gübreleme programlarının oluşturulması için ilave araştırmaların yapılması da önemli görülmektedir.

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Yazarlar herhangi bir çıkar çatışması olmadığını tasdik ederler.

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Derleme

Küresel Isınmanın Çiftlik Hayvanlarında Sürü Sağlığı ve Verimliliği Üzerine Etkisi

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ÖZET

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Bu çalışmada küresel ısınmanın hayvancılık sektöründeki etkisine değinilerek; çiftlik hayvanlarında sürü sağlığı ve verimliliğine mevcut etkileri ve potansiyel riskleri incelenmiştir. Küresel ısınma öncelikle tarım ve hayvancılık sektörünü ve dolayısıyla insanları etkileyen günümüzün en ciddi sorunlarından biridir. Hayvancılık sektörü; sosyal ve ekonomik faydasının yanı sıra hayvansal protein kaynağı olması ile de gıda güvenliği ve güvencesine katkı sağlamaktadır. Hayvan türlerinden elde edilen ekonomik öneme sahip verimler genel olarak çevre faktörlerinden etkilenmektedir. Küresel ısınmanın neden olduğu ani sıcaklık değişimleri, mevsim normallerinin üzerinde sıcaklıkların ortaya çıkması çiftlik hayvanlarında sürü sağlığı ve verimliliğini etkileyerek ekonomik kayıplara sebep olmaktadır. Yerli hayvanlar kısıtlı şartlarda dahi verim elde edilebilen önemli gen kaynaklarımız ve biyolojik zenginliğimizdir. Küresel ısınma ile ani sıcaklık değişimlerinin hayvanlardan alınacak verimi etkilemesi esas alınarak sıcaklık değişimlerine dayanıklı hayvanların yetiştiriciliği ve ıslahı yaygınlaşmalıdır. Sonuç olarak; hayvan yetiştiriciliği faaliyetleri küresel ısınma ile risk altında olup, iklim değişikliği ve küresel ısınmanın potansiyel etkileri göz önüne alınarak yeni önlem ve politikaların geliştirilmesi gerekmektedir.

Anahtar kelimeler: *Küresel ısınma, Çiftlik hayvanları, Isı stresi, Sürü sağlığı*

The Effect of Global Warming on Herd Health and Productivity in Farm Animals

ABSTRACT

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In this study, we discuss the impact of global warming on the livestock sector, examining the current effects and potential risks on herd health and productivity in farm animals. Global warming is one of the most serious issues affecting agriculture and the livestock industry, and thereby, people today. The livestock sector contributes to social and economic benefits and plays a crucial role in ensuring food security by providing a source of animal protein. The economic significance of the yields obtained from livestock species is generally influenced by environmental factors. Global warming, resulting in abrupt temperature changes and temperatures exceeding seasonal norms, adversely affects herd health and productivity in farm animals, leading to economic losses. Domestic animals are important genetic resources and a biological richness that can yield productivity even under limited conditions. Given the impact of global warming and sudden temperature fluctuations on animal productivity, the breeding and selection of heat-resistant animals should be promoted. As a result, livestock farming activities are at risk due to global warming, and new measures and policies need to be developed considering the potential effects of climate change and global warming.

Keywords: *Global warming, farm animals, heat stress, herd health*

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GİRİŞ

Dünyada savaş, pandemi, kuraklık, işsizlik vb. gibi insanoğlunu göçe teşvik eden faktörlerin yanı sıra artan dünya nüfusu da gıda güvenliğini ve güvencesini tehlikeye atmaktadır. Sanayi devrimi ile fabrikaların kurulması, birim alandan daha fazla ürün üretme talepleri ve yığınsal üretim sonucu meydana gelen atık sorunu, doğal kaynakları olumsuz etkilemiştir (Viana ve ark. 2022). Kontrol edilemeyen nüfus artışı ile doğru orantılı olarak artan gıda talebi özellikle uluslararası boyutta gıda sorununu çözmeye yönelik yaptırım ve yatırımları da gerekli hale getirmiştir. Doğaya yapılan insan müdahaleleri sonuç olarak "*küresel iklim sorunu*" olarak ifade edilen güncel bir soruna sebep olmuştur (Galip, 2006; Demir, 2009; Özmen, 2009; Koyuncu, 2017; Koyuncu ve Akgün, 2018; Ahmet, 2019).

Günümüzde dünyanın birçok ülkesinde yaşanan kırsal alandan kente göç sorunu sebebiyle gelişmiş ülkelerde nüfusun yaklaşık %75'i, gelişmekte olan ülkelerde ise %50'inin kent ve çevresinde yaşadığı bildirilmektedir (Bayraç, 2010). Buna bağlı olarak sera gazlarından CO_2, NH_4 ve N_2O gibi bileşiklerin atmosfere salınımı daha da artmıştır(Galip, 2006). Bu sera gazı emisyonlarının atmosferde artması güneş ışınlarını absorbe etmekte ve yeryüzü sıcaklığında tedrici artışlara neden olmaktadır (Demir, 2009).

Tablo 1. *Sera gazlarının küresel ısınmaya etkileri ve emisyon kaynakları*

Sera gazları	Katkı oranı (%)	Emisyon kaynakları
CO_2	50	Fosil yakıtlar Ormanların tahribi
CFC	22	Spreyler Klima ve soğutma sistemleri Elektronik sanayide kullanılan malzeme
CH_4	14	Pirinç tarlaları Hayvanların sindirim sistemleri Biyokütlenin yakılması Çöp sahaları Maden ocakları Doğalgaz boru hattındaki kaçaklar
O_3	7	Trafik Termik santrallerdeki yanma olayları Tropikal ormanların yok edilmesi
N_2O	4	Suni gübreler Fosil yakıtlar Naylon üretimi
Su buharı	3	Okyanus, deniz, akarsu, göller Termal kaynaklar Bitki ve hayvanların solunum ve terlemeleri

(Edemen ve ark. 2023)

Ekonomik büyüme (sanayileşme) ve nüfus artışı ile iklim değişikliği sorunu giderek daha önemli bir sorun haline gelmiştir (Koneswaran ve Nierenberg 2008;Tol 2009; Başoğlu 2014). Hükümetler arası iklim değişikliği paneli (IPCC), 2018 yılında yayınladığı raporunda; sanayi devrimi öncesi dünya sıcaklığının yaklaşık 1ºC artma sebebinin insan aktiviteleri olduğunu ve gerekli tedbirler alınmadığı takdirde ise 2030 ile 2052 yılları arasında ısı artışının 1.5ºC'ye ulaşacağını ön görmektedir (Bellek, 2019). Ayrıca IPCC'nin güncel raporları incelendiğinde, yirmi birinci yüzyıl boyunca gelecekteki sera gazı emisyonlarına bağlı olarak 1.0 ile 3.7°C sıcaklık artışı olacağı tahmin edilmektedir (Koneswaran ve Nierenberg, 2008; Özmen, 2009; Anderson ve ark. 2016).

T.C. Çevre, Şehircilik ve İklim Değişikliği Bakanlığı'nın bildirdiğine göre; insan aktivitelerinin küresel ısınma üzerine etkisi %49 enerji kullanımından, %24 sanayiden, %14 ormanların yakılması ve tahribinden, %13 ise tarımsal faaliyetlerden kaynaklanmaktadır (Galip, 2006; Özmen, 2009). Tarım ve hayvancılıktan kaynaklı toplam sera gazı üretiminin ise sadece %11.9 (62.6 milyon ton) olduğu bildirilmiştir (TÜİK 2018). Çiftlik hayvanlarının yetiştirilmesi ve üretim aşamasında meydana gelen CO_2 emisyonlarının toplamını Dünya Gıda Örgütü (FAO) yılda on milyonlarca metrik ton olarak tahmin etmektedir (Steinfeld, 2006). Hayvansal ürünün türüne göre yakılan fosil yakıt miktarı değişmektedir. Örneğin, 1 kg sığır etinin işlenmesi 4.37 MJ veya 1.21 kilovatsaat gerektirirken, 1 düzine yumurtanın işlenmesi > 6 MJ veya 1.66 kilovatsaat gerektirmektedir (Steinfeld, 2006; Koneswaran ve Nierenberg, 2008).

20. yüzyılın ikinci yarısından itibaren sera gazlarının hızla artarak oluşturduğu küresel ısınma tüm canlıların yaşamını tehdit eden doğa felaketlerine sebep olmaktadır (Öztürk, 2002; Galip, 2006). Yağış, nem, hava hareketleri, kuraklık vb. diğer iklim unsurlarının küresel ısınmayla beraber değişmesi "*küresel iklim değişikliği"* olarak adlandırılmaktadır (Doğan, 2005; Koyuncu, 2017).

Küresel ısınmadan kaynaklı iklim değişikliklerinin ilerleyen süreçlerde hayvancılık sektöründe üretim ve verimliliği azaltabileceği, artan sıcaklıklarla göç mevsimlerinde değişikliklerin olabileceği, belirli bölgelerde eradikasyonu sağlanan hastalıkların tekrar görülebileceği, enfeksiyon etkenlerinin daha hızlı yayılabileceği ve hayvanların bu enfeksiyonlara cevap verme sürelerinin uzayacağı tahmin edilmektedir. Ayrıca küresel ısınma ekolojik dengenin bozulması ve biyolojik çeşitliliğin azalmasına neden olacaktır (Ali ve ark. 2020; Sarıözkan ve Küçükoflaz, 2020; Balasundram ve ark. 2023).

Hayvansal üretimde ve yetiştirmede kullanılan sistemler tarafından sera gazı salınması ile küresel ısınmaya katkıda bulunan ama aynı zamanda küresel ısınma sonucunda meydana gelen faktörlerden olumsuz olarak etkilenen hayvancılık faaliyetleri tehdit altındadır (Naqvi ve Sejian, 2011). Hayvancılıkta enterik fermantasyon ve depolanan gübre nedeniyle oluşan CH_4 ile N_2O gazları sera etkisine neden olmaktadır.

Hayvancılık faaliyetlerinin olumsuz etkilerinin azaltılması ve küresel ısınmanın hayvancılık üzerine etkisi birçok araştırmacı incelemiştir (Koneswaran ve Nierenberg, 2008; Kılıç ve Karaman, 2014; Koyuncu, 2017; Koyuncu ve Akgün, 2018; Ahmet, 2019; Wankar ve ark. 2021).

Hayvansal üretime talep

İklim değişikliğinin tarım ve hayvancılık sektörünü olumsuz etkilemesinden dolayı Türkiye gibi gelişmekte olan ülkelerin ekonomisi daha çok etkilenmektedir (Sarıözkan ve Küçükoflaz, 2020).

İklim değişikliğiyle bitkisel üretimin olumsuz etkilenmesi tarım alanlarını azaltmakta bu da hayvanların yem ihtiyaçlarının karşılanmasını zorlaştırmaktadır (Mirón ve ark. 2023). Nüfusun artışının aksine bitkisel üretimin azalması üretim maliyetlerini artırmaktadır. Hayvancılıkta arzın azalıp talebin artması, oluşan bu talebi karşılamak için canlı hayvan ve et ithalatının artmasına ve ürün fiyatlarının yükselmesine sebep olmaktadır (Başoğlu, 2014; Sarıözkan ve Küçükoflaz, 2020).

Hayvansal kaynaklı gıdaya artan bu talep hayvancılık sektörünün geleneksel yetiştiricilikten entansif yetiştiriciliğe kaymasına zemin hazırlamıştır. Aynı zamanda entansifleşen hayvancılık sektörü ile hayvancılığın sera etkisindeki payı artmıştır (Gerber ve ark. 2013; Sarıözkan ve Küçükoflaz, 2020). Türkiye'de yapılan bir araştırmada (Sarıözkan ve Küçükoflaz, 2020), toplam 47 870 234 ton CO_2 gazı salındığı hesaplanmıştır. Bunun en büyük payını %43.9 ile süt üretimi oluştururken %30.8' ini kırmızı et, %16.3' ünü kanatlı eti ve geri kalan %9' unu yumurta üretimi oluşturmaktadır.

Sıcaklık değişimlerinin hayvancılık sektörüne etkisi

Son yıllarda hayvancılık sektöründe verimlerin iyileştirilmesi, çevrenin uyumlu hale getirilmesi ve beslenme programlarının düzenlenmesine yönelik yapılan çalışmalar hayvanlarda verimi arttırırken, öte yandan ısı stresine karşı hassasiyetlerini de arttırmıştır (Bernabucci, 2019).

Küresel ısınmadan ve iklim değişikliklerinden kaynaklanan zorlu hava şartları hayvanların verimlerini azaltmanın yanı sıra yaşama güçlerini de olumsuz yönde etkilemektedir (Koyuncu, 2017). Bu kayıplar hem ekonomik kayba hem de gerekli besinlerin alımına engel oluşturmaktadır. Birçok araştırma sıcak ve nemli ortamların salgın hastalıkların yanı sıra çiftlik hayvanlarında strese neden olacağını bildirmektedir (Puvadolpirod ve Thaxton, 2000; Parsons ve ark. 2001; Lacetera ve ark. 2003; Çınar ve ark. 2006;Dönmez ve Atalay, 2007; Dönmez ve ark. 2007,Akyuz ve ark. 2010; Burger, 2010).Ayrıca hayvanların iklim değişikliğine uyum sürecinde küresel ısınmanın; bağışıklık sisteminin baskılanması, yem tüketiminde azalma, canlı ağırlık kazancında azalma, sağlığın bozulması, üreme etkinliğinin yavaşlaması ve verimin düşmesi ile birçok davranışsal ve metabolik değişimlere sebep olacağı belirtilmektedir.

Tablo 2. *Çiftlik hayvanlarında bazı türlere ait canlı ağırlık ve yaşa göre değişen en düşük ve en yüksek çevre sıcaklığı değeri sınırları*

	Sıcaklık değeri sınırları (^{o}C)	
	En düşük	En yüksek
Sütçü sığırlar	-12/-1*	24
Yeni doğan buzağı	8-10	35
Büyüme çağındaki domuz, 35-75 kg	15	25
Sow, boar > 100 kg	10	25
1 günlük yaştaki civciv	32	35
Yumurtacı tavuk	16	27-29
Etlik piliç	16	26
1 günlük yaştaki hindi palazı	35	38
Yetişkin hindi	16	26

*: En düşük kritik sıcaklık değeri Holstein ve Brown Swiss ırkı için -12 ^{o}C, Jersey ırkı için -1 ^{o}C'dir. *(Babinszky, 2011)*

Çiftlik hayvanları türlere göre değişse de genel olarak sıcaklığın 10-25 °C olduğu zamanlarda en iyi performanslarını sergilediği söylenebilir (Tablo 2). Ortam sıcaklığında 30°C'nin üzerindeki her 1°C'lik artışla sığır, koyun, keçi ve tavukların yem tüketimlerinde ortalama %3-5 düzeyinde bir azalmanın olduğu ifade edilmektedir (Koyuncu, 2017).

Sıcak hava hayvanlarda ısı stresine yol açacağı için hayvanlarda refah problemine neden olabilir. Sıcaklık artışlarının hayvanlar üzerindeki etkisini tedavi etmek yerine sürüyü korumaya yönelik önlemlerin alınması daha kolay, ekonomik ve sürdürülebilir bir yoldur. Hayvan barınaklarına yeterli ve kaliteli su, yeterli ve dengeli beslenme, hayvan başına gerekli alan, gölgelikler ve havalandırma uygulamaları gibi çevre faktörleri iyileştirilmeli ve kontrollü sürü yönetimi uygulamaları gerçekleştirilmelidir. Sıcaklık artışlarının hayvanlar üzerindeki olumsuz etkileri ancak yetiştiricinin ilgi, şefkat ve önlemleri ile minimize edilebilir (Kerr, 2015).

Süt ve besi sığırlarında etkisi

Dünya'da her üç kişiden biri hayvansal protein ihtiyacını sığırlardan karşılamakta iken dünya nüfusunun %17'den fazlası ise ekonomik kazançlarını bu türe ait verimlerden karşılamaktadır (Wu and Etienne, 2021).Yaklaşık %50'si tropik bölgelerde bulunan sığırların ürettiği sera gazı emisyonu, hayvancılıktan kaynaklanan toplam emisyonun yaklaşık %65'ini (4.6 milyar ton CO_2 eşdeğeri) oluşturmaktadır. Süt sığırı işletmelerinin yaklaşık %60'ı küresel ısınmanın oluşturduğu sıcaklık stresinden etkilenmektedir (Koyuncu ve Akgün, 2018).
Mallonee ve ark. (1985)'ı ineklerin yem tüketimi oranının sıcak havalarda ve gündüz saatlerinde, gece saatlerine göre %56 oranında azaldığını bildirmişlerdir. Aynı çalışmada, açık havada tutulan sığırlarda gece boyunca yem tüketimi kapalı alanda tutulan sığırlara göre %19 oranında artmış, genel yem tüketimi ise %13 daha az olmuştur (Bajagai, 2011).

Yüksek verimli sığırların zorlu iklim koşullarına uyum çabası, düşük ısıyı tolere etmesi ve üretim seviyelerinin stresten önceki verimlerine dönememesi sıcaklık stresine duyarlılıklarını arttırmaktadır (Kadzere ve ark. 2002; Spiers ve ark. 2004; Thornton ve ark. 2009). Küresel ısınma ve iklim değişikliği ile azalan yem tüketimi %35, sıcaklığın artmasıyla oluşan stres %65 oranında süt veriminin kalite/kantitesinin olumsuz etkilenmesine ve laktasyon süresinin kısalmasına sebep olmaktadır (Klinedinst ve ark. 1993; Nardone ve ark. 2010; Bajagai, 2011). Süt üreten sığırlarda üretim arttığı için metabolik ısı çıkışı artacağından bu sığırlarda sıcaklık stresine duyarlılık azalmaktadır. Örneğin, 18.5 ve 31.6 kg/gün süt üreten ineklerde metabolik ısı çıkışı, emzirmeyen ineklere göre %27.3 ve %48.5 daha fazla olmaktadır (Purwanto ve ark. 1990; Berman, 2005). Ayrıca süt üretimi 35 kg/gün'den 45 kg/gün'e çıktığında ısı stresi için eşik sıcaklık değeri 5°C düşmektedir (Berman, 2005). Sağmal sığırlarda Temperature humidity ındex (THI) değerinin 68'e ulaşması hayvanların strese girmesine sebep olmakta, 79 ve üzerine çıkması ise sıcaklık stresini ciddi bir sorun haline getirmektedir (Zimbelman ve ark. 2009). Ayrıca yaz aylarında sütçü sığırlarda süt veriminde ve gebelik oranında (%36'lık), besi sığırlarında ise yem alımının azalmasıyla negatif enerji dengesinde ve canlı ağırlık artışında azalma olduğu saptanmıştır (Nardone ve ark. 2010; Bernabucci, 2019).

Sıcaklığın artmaya başlamasıyla vücut sıcaklığı ve ısı yükü artmakta, derideki sinyaller hipotalamusa iletilmektedir. Vücut sıcaklığının düzenlenmesi için çalışan ter bezleri senkronizatör gibi rol oynamaktadır.

Buna destek olarak soluma hızında ve salya üretiminde artış şekillenmektedir. Soluma yoluyla sağlanan ısı kaybı vücut içi sıcaklığını sağlamada %15 rol oynadığı bildirilmektedir (Alkoyak ve Cetin, 2016).

Artan CO_2 seviyeleri, sıcaklığın artması ve değişen yağış rejimi besi hayvanlarının sağlığı ve üretkenliği üzerinde önemli bir etki oluşturmaktadır (Balasundram ve ark. 2023). Yüksek sıcaklıktan kaynaklı hayvanlarda üretilen tükürük miktarı ve HCO_3 içeriğindeki azalma rumene giren tükürük miktarını azaltacağından yem alımında düşmeye neden olmaktadır. Bu durumda hayvanların subklinik ve akut rumen asidozuna karşı duyarlılıkları artmaktadır (Nardone ve ark. 2010). (Wittmann ve ark. 2001)'ına göre, sıcaklık değerlerindeki 2 °C'lik bir artış mavi dil virüsünün ana vektörü *Culicoides imicola'nın* önemli oranda yayılma olasılığını arttırdığını ortaya çıkarmıştır. Hava sıcaklığının yüksek olduğu dönemlerde meme bezi enfeksiyonuna sebep olan patojenlerin hayatta kalma süresi ve çoğalmasının artması mastitise yakalanma riskini arttırmaktadır (Koyuncu, 2017). Buna yönelik Bangladeş'te yapılan bir çalışmada Kaliforniya mastitis testiyle test edilen ineklerde subklinik mastitis %24-44 oranında görülmüş ve bu büyüyen süt sığırcılığı işletmelerinde sorun teşkil etmiştir (Islam ve ark. 2010; Ali ve ark. 2020).

Resim 1. *Küresel ısınma sonucu artan sıcaklıkların sığırlar üzerindeki etkileri*

Sütçü sığırların üremesi üzerine doğum sonrası sıcaklık stresi Resim 1.'de verilmiştir. Küresel ısınmaya bağlı sıcaklıklardaki artışın neden olduğu ısı stresi ile yüksek bağıl nem ya da her iki faktörün aynı anda etkilenmesi daha kısa kızgınlık periyoduna, zayıf kızgınlığa sebep olup; östrusların tespit edilememesinden dolayı tohumlamalar arası sürenin uzamasına, döl veriminde azalmaya ve daha yüksek anöstrus göstermelerine sebep olmaktadır (Hansen ve Areéchiga, 1999; De Rensis ve Scaramuzzi, 2003; Jordan 2003; Morton ve ark. 2007; Avendaño-Reyes ve ark. 2010). Aynı zamanda yüksek sıcaklık ile artan vücut sıcaklığı döllenme oranında düşme, embriyonik gelişmede yavaşlama ve erken embriyonik ölümlerde artışa sebep olmaktadır (Lacetera ve ark. 2003).

Koyun ve keçilerdeki etkisi

Keçilerin yılda yaklaşık 5.0 kg metan gazı ürettiği bildirilmiştir (Monteiro ve ark. 2018; Van Thu, 2018). Küresel düzeyde farklı coğrafi alanlara yayılışlarına bakılacak olursa koyun ve keçilerin diğer ruminantlarla karşılaştırıldığında çevresel stres faktörlerine daha iyi uyum sağladıkları görülmektedir (Demir ve ark. 2022). Çevre koşullarına uyum sağlamada rol oynayan tiroit hormonlarından T_3 ve T_4 seviyesinin azalması keçilerde metabolizmayı yavaşlatıp enerji üretimini azaltmaktadır (Darcan ve Daşkıran, 2010).

Yem kaynaklarındaki azalma annenin gebelik öncesi ve sırasında yetersiz beslenmesine, bu durumda yetersiz plasenta oluşumuna ve fetüsün büyümesinde yavaşlamaya, süt veriminde azalmaya ve yavrunun doğum ağırlığının düşmesine neden olmaktadır (Robinson ve ark. 1999; Dwyer, 2003; Greenwood ve Bell, 2003; Dwyer ve Lawrence, 2005).

Sıcak stresi gibi soğuk stresi de hayvanlar üzerinde olumsuz etkiler oluşturmaktadır. Soğuk stresi yeni doğan kuzu ve oğlaklarda mortalite oranını yükseltirken sıcak stresi de solunum hızının artmasını ve beraberinde düzensiz solunumu oluşturmaktadır (Riesenfeld ve ark. 1996; Khalek ve Khalifa, 2004).

Kanatlı sektörüne etkisi

Dünya nüfusunun artmasıyla birlikte gıda talebinin artması ve hayvansal proteine olan ihtiyacın oluşması, kanatlı ürünlerini popüler hale getirmektedir (Açıkgöz ve Özkan, 1996). Kanatlı sektörünün küresel ısınmaya katkısı hayvanların metabolizması sonucu ortaya çıkan atıklardan ve ölü hayvanlardan kaynaklanmaktadır. Gübre, işletme atıkları, atık sular, ölü hayvanlar ve koku, sinek gibi sorunlara çözüm oluşturulması kanatlı sektörünün sürdürülebilirliği için önem taşımaktadır (Altan ve ark. 1996; Kılıç ve Karaman, 2014).

Hayvanlarda refah koşulları hayvansal ürünlerin niteliğini belirlediğinden gözlemlenen stres hayvanlarda refah şartlarının iyi olmadığının bir göstergesi olarak kabul edilmektedir (Bozkurt, 2016). Stres fonksiyonel sistemlerde homeostazinin bozulmasına neden olmaktadır. Kanatlılarda ısı stresi sonucu vücut sıcaklıkları ve periferik kan akışları artarken viseral kan dolaşımları azalmaktadır. Isı stresi sonucunda görülen bu değişiklikler yem tüketiminde, yemden yararlanma oranında, canlı ağırlık kazancında, tavuk etinin protein ve enerji içeriğinde ve kuluçka randımanında azalma görülmesine sebep olmaktadır (Tankson ve ark. 2001; Sarıca, 2011; Hu ve ark. 2019).

Artan sıcaklık sonucu uterusa giden kan miktarı azalmaktadır. Döllülük oranı düşmekte, erken embriyonik ölümler ise artış göstermektedir. Kuluçka haricinde yumurta kalite özelliklerinde de östrus siklusu sırasında LH, FSH ve progesteron salınımı değiştiğinden yumurta hücre oluşum ve gelişim süreçleri olumsuz etkilenerek yumurta ağırlığı, kabuk ağırlığı, yumurta verim ve bazı kalite özellikleri olumsuz etkilenmektedir. (Novero ve ark. 1991; Lacetera ve ark. 2003; Mashaly ve ark. 2004; Nardone ve ark. 2010). Ayrıca küresel ısınmayla beraber değişen mevsim normallerinin göç eden yabani kuş türlerinde yumurtlama döneminin 5 gün erkene çekildiği ve göç etme sürelerinin ise 2-3 gün geciktiği bildirilmektedir (Koyuncu ve Akgün, 2018).

Sıcaklığın artmasıyla enfeksiyona sebep olan patojenlerin yaşam sürelerinin uzaması ve vektörlerin artması, hastalıkların oluşmasına sebep olmaktadır. Kanatlıların hastalıklara karşı duyarlı olması hastalıklar sonucunda ölüm oranlarını artırmakta ve ekonomik kaybı oluşturmaktadır (Wittmann ve ark. 2001; Nardone ve ark. 2010; Al-Amin ve Alam, 2011).Türkiye'de mayıs-haziran aylarındaki küresel ısınmaya bağlı artan yağışların özellikle keklik civcivlerini olumsuz etkilediği ve kekliklerin sayısını azalttığı bildirilmiştir (Kırıkçı, 2016).

Isı stresinin sebep olduğu canlı ağırlık kazancındaki azalma, patojenlerin artması gibi olumsuzlukları azaltmak ve yok etmek için araştırıcılar farklı stratejiler belirtmekte ve yeni yetiştirme sistemleri araştırılmaktadır (Ghanima ve ark. 2020). Bu yaklaşımlardan biri olan diyet takviyesi üretim performanslarını iyileştirmek için, sıcaklık stresiyle mücadele içinse vitaminler, mineraller, probiyotikler ve bitkisel ürünler gibi katkı maddelerinin kullanılması önerilmektedir (Sahin ve ark. 2006; Tang ve ark. 2018; Goel, 2021).

Kanatlılar radyasyon, evaporasyon (buharlaşma), kondüksiyon (fiziksel temas), iştah kaybı ve su alımını arttırma yoluyla vücut ısılarını dengede tutmaya çalışmaktadır. Kümeste yerleşim sıklığının fazla olması ve yetersiz havalandırma koşullarında radyasyon yoluyla ısı kaybını engellemektedir. Evaporasyon yoluyla ısı kaybında enerji artacağından ısı kaybı şekillenmekte ama üretimde kayıplara sebep olabilmektedir. Kondüksiyon yoluyla kuru altlık zemine ulaşmalarını sağlayarak ısı kaybını kolaylaştırmakta ama ek olarak yerden soğutma sistemleriyle destek sağlanmalıdır. Islak altlık ısı kaybını azalttığı için altlık kontrolleri yapılmalıdır. Isı stresi sonucu yem alımında azalma ve su alımında artma gözlenmektedir (Akçapınar ve Özbeyaz, 1999; Kapetanov ve ark. 2015).

SONUÇ VE ÖNERİLER

Teknolojinin gelişmesi, insanların yaşam standardını yükseltme isteğini artırarak, kaynakların sınırsız olabileceği düşüncesiyle, insanoğlunu üretim yerine tüketim anlayışına yöneltmiştir. Küresel ısınmanın etkileri tarım ve hayvancılık sektörlerini etkileyerek, insanoğlunun mevcut gıda güvenliği ve güvencesi

endişelerini daha da artırabilir. Hayvansal üretim faaliyetlerinin emisyon kaynakları içindeki payı değerlendirildiğinde, araştırıcıların hayvan yetiştiriciliğinin çevre tahribinden önce CO_2 ve CFC kaynaklarının çözümüne ilişkin sürdürülebilir politikalara odaklanması gerekmektedir. Hayvansal üretim kırsal nüfusun geçim kaynağı olduğu gibi dünyadaki her üç kişiden birinin protein kaynağı da olduğu unutulmamalıdır.

Hayvansal protein ihtiyacı her geçen gün artmaya devam etmektedir. Hayvanlardan elde edilen ekonomik öneme sahip her verim çevre şartları göz ardı edilerek değerlendirilmemelidir. Her canlı çevre ile etkileşim halinde olduğuna göre çevre şartlarının değişimleri, hayvanların morfolojik, fizyolojik ve davranışsal özelliklerini değiştirmektedir. Yerli hayvanlar kısıtlı şartlarda dahi verim gösterebilen önemli gen kaynaklarımızdandır. Yerli hayvanlar üzerinde gösterilecek çaba ve araştırmalar, canlı türlerinin korunmasını sağlayarak biyolojik çeşitliliğin azalmasını önlemeye bir tedbir olarak değerlendirilmelidir. Küresel ısınma ile ani sıcaklık değişimlerinin hayvanlardan alınacak verimi etkilemesi referans olarak alınıp sıcaklık değişimlerine dayanıklı hayvanların yetiştiriciliği ve ıslahı yaygınlaşmalıdır.

Sonuç olarak; hayvan yetiştiriciliği faaliyetlerini durdurmayı hedefleyen bir anlayışın harekete geçmesi, insanoğluna sosyal, ekonomik ve sağlık yönünden faydadan çok zarara neden olabilir.

ÇIKAR ÇATIŞMASI

Yazarlar herhangi bir çıkar çatışması olmadığını tasdik ederler.

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Tüm yazarlar eşit katkı sağlamıştır.

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Derleme

Küresel İklim Değişiklikleri ve Süt Sığırı Yetiştiriciliği

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ÖZET

MAKALE BİLGİSİ

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Küresel iklim değişiklikleri atmosfere salınan gazların sera etkisi oluşturması ile son zamanlarda tüm üretim sistemlerini yakından ilgilendiren bir konudur. Küresel ısınmanın önlenememesi bitki ve hayvan çeşitliliği, üretim sistemleri, ekosistemler ve gıda güvenliği üzerinde risk oluşturmaktadır. Bu ısınmanın etkileri (mevsime bağlı mera kullanımları, yem miktarı ve kalitesi, besleme yöntemleri, vb.) doğrudan ya da dolaylı olarak görülmektedir. Aşırı sıcak dönemlerin uzunluğu tüm dünyada etkisini göstermekte olup hayvancılık üretim sistemlerinde çeşitli zorluklara neden olmaktadır. Bu derlemede iklim değişikliğinden kaynaklanan süt sığırcılığı üretim sistemlerine yönelik gereksinimler ele alınmıştır. İklim değişikliklerinin süt sığırcılığı üzerine olan potansiyel etkilerinin hayvan refahı, beslenmesi, sağlığı ve üretim performansı olarak incelenmesi amaçlanmıştır. Doğrudan veya dolaylı olarak görülebilecek tüm etkiler hayvanın performansı ile ilişkili olmaktadır. Yüksek verimli süt inekleri bu etkilere karşı daha savunmasız bir durumda yer almaktadır. Bu etkilerle başa çıkılması için farklı düzeylerde faaliyete geçirilmesi gereken çeşitli adaptasyon yöntemleri ve ısı yükünü azaltma stratejileri planlanmalıdır. Yapılacak olan tüm değişiklikler üretim sistemlerindeki değişiklileri, farklı yönetim seçeneklerini ve sağlık yönetimlerini içermektedir.

Anahtar kelimeler: *Küresel ısınma, Süt sığırı, Sıcaklık stresi, Adaptasyon*

Global Climate Change and Dairy Cattle Breeding

ABSTRACT

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Global climate change is an issue that has recently been of great concern to all production systems due to the greenhouse effect of gases released into the atmosphere. Failure to prevent global warming poses a risk to the diversity of plants and animals, to production systems, to ecosystems and to food security. The effects of this warming are seen directly or indirectly (seasonal pasture utilization, feed quantity and quality, feeding methods, etc.). The length of extreme hot periods is affecting all over the world and causing difficulties in livestock production systems. This review addresses the requirements for dairy cattle production systems resulting from climate change. It is aimed to examine the potential impacts of climate change on dairy cattle in terms of animal welfare, nutrition, health and production performance. All effects that can be seen directly or indirectly are related to the performance of the animal. High yielding dairy cows are more vulnerable to these impacts. In order to cope with these effects, various adaptation methods and heat load reduction strategies should be planned to be activated at different levels. All changes include changes in production systems, different management options and health management.

Keywords: *Global warming, Dairy cattle, Heat stress, Adaptation*

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GİRİŞ

Gelecekteki iklim koşulları için Orta Avrupa gibi ılıman iklim bölgelerinde bile özellikle yaz aylarında sıcak dönemlerin ve kuraklıkların artacağı tahmin edilmektedir. Hükümetlerarası İklim Değişikliği Paneli'nin (IPCC) Beşinci Değerlendirme Raporuna göre, küresel ortalama yüzey sıcaklığı 2100 yılına kadar 0,3°C ila 4,8°C aralığında artacaktır (IPCC, 2014). Sıcaklık stresine yol açan günlerin sıklığı son yıllarda artmıştır (Solymosi ve ark., 2010). Bununla birlikte iklim değişikliğinin etkileri bölge, süre ve dağılım açısından farklıdır. Ayrıca hayvan türleri, ırklar ve bireyler arasındaki etkiler de farklıdır. Bu nedenle her bölgenin ilgi alanı, tür ve sistem yoğunluğu için temel faktörler tanımlanmalıdır.

İklim değişikliği hayvan refahı, fizyolojisi, sağlığı ve üremesi üzerine etkilidir. Bu etkilerin görülmesinde sıcak hava dalgalarının sıklığı, sıcak dönemlerin fazlalığı ve aşırı iklim koşullarının görülmesi gibi faktörler rol oynamaktadır (Zampieri ve ark., 2016). Bu faktörler süt veriminin yanında sütün bileşimini ve peynir, yoğurt gibi elde edilebilecek işlenmiş süt ürünlerinin miktarı ile kalitesini de etkileyerek önemli oranda ekonomik kayıplara neden olmaktadır (Cowley ve ark., 2015). Bu etkilerin önlenebilmesi için ısı toleransına sahip olan hayvanların yetiştirilmesi, beslenme adaptasyonlarını ve sağlık bakım faktörlerini içeren yetiştirme yöntemlerinin geliştirilmesi gerekmektedir. Geliştirilecek olan yöntemlerin iklim değişikliği ile ilgili olan etkileri azaltabileceği ifade edilmektedir (Fitzgerald ve ark., 2009; Gauly ve Amber, 2020).

İKLİM KOŞULLARININ HAYVANLAR ÜZERİNDEKİ ETKİLERİNİN ÖLÇÜLMESİ

Sığırlar üzerindeki iklim koşullarının potansiyel etkileri; çevre koşullarının, hayvana ait özelliklerin ve her ikisinin kombinasyonunun kullanılmasıyla değerlendirilebilir. Çevre koşullarına ait faktörler bağıl nem, sıcaklık, güneş ışınları, yağış ve rüzgardır. Bunların kombinasyonunu içeren endeksler termal konfor bölgelerinin tahmin edilmesi ve ısı yükünün hayvanlar üzerindeki etkilerinin ölçülmesi için kullanılmaktadır. Bazı parametrelerin geçerliliği ve kullanılabilirliği sınırlı olduğundan daha çok hava sıcaklığı ve bağıl nem gibi kolay ulaşılabilir olan veriler tercih edilmektedir. En sık kullanılan endeks sıcaklık ve bağıl nemi birleştiren Sıcaklık Nem Endeksi'dir (Temperature-Humidity-Indeks (THI)) (Gauly ve Amber, 2020).

Süt sığırlarında termal konfor veya rahatsızlık değerlendirmesi için THI yaygın olarak kullanılmasına rağmen, bu endeksin geçerlilik, duyarlılık ve güvenilirlik açısından kullanımına ilişkin bazı sınırlamalar vardır. Bölgenin ve çiftliklerin içinde bulunduğu çevre şartlarının çeşitliliği, hayvana ait bireysel özellikler (verim, gebelik…), hayvanın sıcaklık stresine karşı savunma düzeyi gibi faktörler ısı stresinin oluşumunu değerlendirmek için yalnızca THI'nin güvenilir bir şekilde ölçülmesinin yeterli olmadığını göstermektedir (Renaudeau ve ark., 2012). Bu nedenle, süt sığırlarında sıcaklık stresi değerlendirilirken, hayvana ait özellikler de dikkate alınmalıdır. Fizyolojik değerlerdeki değişiklikler (vücut ısısının ve solunum hızının artması gibi) kısa süreli sıcak dönemlere verilen tepkiler hakkında bilgi verirken, uzun süreli sıcak dönemlerin etkileri hayvan davranışı ve performansı (günlük aktivitelerin azalması, dinlenme davranışının artması, günlük süt veriminin düşmesi, içme davranışının ve süresinin artması, gölge arama gibi) üzerinde görülen değişikliklerle ortaya çıkmaktadır (Cook ve ark., 2007; Lambertz ve ark., 2014; Ammer ve ark., 2017).

Sığırlarda vücut sıcaklığının ölçülmesinde en yaygın olarak kullanılan rektal sıcaklığı vajinal sıcaklık ve süt sıcaklığı takip etmektedir (Liang ve ark., 2013; Galán ve ark., 2018). Vücut sıcaklığının ölçüldüğü diğer yerler arasında meme, işkembe, periton veya kulak zarı yer almaktadır. Vücut ısısı ölçümü mevsim, saat, iklim koşulları, cins, süt verimi, su ve yem alımı ve hatta ölçüm yöntemi gibi faktörler tarafından etkilenmektedir (Liang ve ark., 2013; Ammer ve ark., 2016).

PERFORMANS, ÜRÜN KALİTESİ VE ÜREME

İklim koşullarının bireysel termonötr seviyesini aştığı durumlarda organizmanın ısı dağılımı ve vücut sıcaklığı artmaktadır. Bu etki performansı da etkilemektedir. Hiperterminin seviyesi süt üretimi ile oldukça ilişkilidir. Genel olarak süt sığırları için termonötr bölgenin alt ve üst sınırlarının ölçülmesi mümkün olmamaktadır. Ortam ısısı ile yem tüketimi arasındaki negatif ilişki yüksek süt verimini etkilediği için önemlidir. Ortam ısısının yüksek olması yem tüketimini azaltır, sığırın ısı üretiminde bir azalma yaratır ve bu azalma termal yükün dengelenmesi için gereklidir. Dolayısıyla yüksek verimli süt sığırları sıcaklık stresine karşı diğerlerine göre daha savunmasız bir haldedir (Zimbelman ve ark., 2010). İklim değişikliklerinin süt

verimine etkisinin ortaya çıkması için zamana ihtiyaç vardır. Kuru madde alımında ve süt veriminde görülen düşüşün, ölçümden 2 gün önceki sıcak koşullardan kaynaklandığı tahmin edilmektedir (West ve ark., 2003). Bouraoui ve ark. (2002), gün içindeki sıcaklık nem endeksinin süt verimine ilişkisinin -0.76 oranında, yem alımına ilişkisinin -0.24 oranında olduğunu belirtmiştir. Endeksin 69'u aştığı durumlarda ise endeks birimindeki her bir birimlik artışın inek başına alınacak olan günlük süt verimini 0.41 kg azalttığı da ifade edilmiştir. Süt sığırı işletmelerinin yaklaşık %60'lık kısmının sıcaklık stresinden etkilendiği ve meydana gelen verim ve performans düşüklüğüne bağlı olarak önemli ekonomik kayıplara yol açtığı düşünülmektedir (Koyuncu ve Akgün, 2018).

Süt verimine ek olarak inorganik ve organik süt bileşenlerine de iklim etkilerinin sonuçları incelenmiş ve süt laktozunda herhangi bir etkinin tespit edilmediği belirtilmiştir (Cowley ve ark., 2015). Sıcaklık stresinin süt yağ içeriği üzerine etkisi için; Liu ve ark. (2017), fosfolipid seviyelerinin düştüğü sonucuna, Cowley ve ark. (2015) ise süt yağ oranında herhangi bir değişiklik oluşmadığı ancak süt proteini ile kazein içeriğinin azalma eğiliminde olduğu sonucuna varmışlardır. Bu etkiler özellikle çiğ süt kullanımında sütün pıhtılaşma özelliklerini ve peynir üretim süreçlerinin verimliliğini olumsuz etkilemektedir. Mariani ve ark. (1993), rasyon içeriğinde bulunan yem maddelerinin çeşitli mevsimsel faktörlerden etkilenerek sütün mineral içeriğinde değişiklikler oluşturabileceğini belirtmişlerdir. Sıcaklık stresi yaşayan ineklerden elde edilen süt aynı zamanda daha düşük kalsiyum, fosfor ve magnezyum ile daha yüksek pH, klorür, donma noktası ve plazmin aktivitesine sahiptir.

Süt sığırı yetiştiricileri için sıcaklık stresinin en önemli etkilerinden birisi de süt sığırlarının döl verim performansında görülebilecek bozukluklardır. Görülen bozukluğun temel sebebi sıcaklık stresine bağlı olarak vücut sıcaklığındaki artıştır. Sıcaklık stresinin döl verimi üzerindeki etkileri açık gün sayısındaki artış, anöstrusa bağlı olarak doğurganlığın azalması ve gebe kalma oranlarının azalmasını içermektedir (Kadokawa ve ark., 2012). İn vivo ortamda yapılan çalışmalar tohumlama gününde yaşanacak olan yüksek sıcaklıklar ile gebelik oranları arasında pozitif bir ilişki olduğunu ortaya koymuştur (Nabenishi ve ark., 2011). Sakatani ve ark. (2015), sıcaklık stresinin inek oositlerinin döllenmesi üzerindeki etkisini tahmin etmek için bir in vitro model kullanmış ve ortaya çıkan oksidatif stresin polispermiye yol açarak zigotun daha fazla gelişme kapasitesini azalttığı sonucuna varmıştır. İleri evredeki embriyoların (morula, blastosist) belirli bir termotolerans düzeyi kazandığı da belirtilmiştir (Paes ve ark., 2016). Östrus gösteren ineklerde yapılacak olan suni tohumlamada GnRH uygulaması ile gebe kalma oranlarında iyileştirmeler sağlanabileceği ifade edilmiştir (López-Gatius ve ark., 2006; Gauly ve Amber, 2020). Akbarabadi ve ark. (2014), ise bu tür hormon uygulamalarının etkisinin sıcaklık stresi altındaki inekler için tartışmalı olduğunu belirtmiştir. Artan ısı yükünün bir ineğin üreme fizyolojisi üzerine sadece kısa vadeli değil, aynı zamanda uzun vadeli etkilerinin de olabileceği unutulmamalıdır (Safa ve ark., 2019).

Boğalar için ise sıcaklık stresinin etkileri motilite oranlarında azalma ve morfolojik olarak anormal spermlerin sayıca artışı olarak ortaya çıkmaktadır (Malama ve ark., 2017). Sabés-Alsina ve ark. (2019), dondurulup çözülmüş spermanın sperm kalitesi üzerine yaptıkları çalışmada, İsveç ve İspanya'da kış (Aralık-Ocak), ilkbahar (Mart-Nisan) ve yaz (Temmuz-Ağustos) aylarında sperm toplayarak, sperm kalite parametrelerinin, sperm toplama ayına göre sperm toplanmasından 1 veya 2 ay önceki iklimsel faktörlerle daha fazla ilişkili olduğunu göstermiştir.

HAYVAN SAĞLIĞI, DAVRANIŞ VE REFAH

İklim değişikliklerinin hayvan sağlığı, davranışı ve refahı üzerindeki etkileri doğrudan ya da dolaylı olarak görülmektedir. Etkiler hayvanların genetik materyali, maruz kalma düzeyi ve fiziksel durumu gibi faktörler tarafından değişmektedir. Hayvanın verimliliği arttıkça strese karşı duyarlılık ile kırılganlığın ve bununla birlikte sağlık, davranış ve refah üzerindeki etkinin arttığı öne sürülmektedir (Sanker ve ark., 2013). Yoğun üretim sistemlerindeki hayvanların, uyum stratejilerinin mevcut olmadığı, az gelişmiş ülkelerdeki kapsamlı sistemlere kıyasla daha az etkilenebileceği ifade edilmektedir (Rust, 2019).

Hayvan sağlığı, sıcaklığa bağlı görülebilecek hastalık ve ölüme yol açan iklim koşullarından doğrudan etkilenmektedir. Bu etkiler bağışıklık ve hormonal sistemdeki değişikliklerden kaynaklanmaktadır (Das ve ark., 2016). Yaz aylarında artan sıcaklık ve nem değerleriyle birlikte mevsimin sütteki somatik hücre sayısını etkilediği ve ayrıca meme içi enfeksiyon görülme riskini arttırdığı bildirilmektedir (Bertocchi ve ark., 2014; Testa ve ark., 2017).

Sıcaklık stresi yaşayan sığırlarda, konsantre yem tüketiminin artması gibi beslenme davranışında görülebilecek değişiklikler asidoz oluşumuna sebebiyet verebileceği gibi topallığın ortaya çıkmasına da neden olabilir (Enemark ve ark., 2002). Buna ek olarak, yüksek verimli süt sığırlarında yem alımındaki azalma ile bakım ve performans için gereken yüksek enerji ihtiyaçları yaz aylarında subklinik veya klinik ketozis yaşama riskini arttırmaktadır (Lacetera ve ark., 1996).

İklim değişikliklerinin hayvan davranışları ve refahı üzerindeki dolaylı etkileri karmaşık olduğundan ölçüm ve belirleme amacıyla daha az kullanılmaktadır. Bu etkiler yemin ve suyun varlığı, kalitesi, patojen ve vektörlerin miktarı gibi faktörlerden etkilenmektedir. Polsky ve von Keyserlingk (2017), sıcaklık stresiyle ilişkili ağrı, hayal kırıklığı, saldırganlık ve halsizliğin, özellikle kısa vadede artan açlık ve susuzluğun, uzun vadede ise ayak lezyonları ve topallığın iyi anlaşılması için daha fazla araştırmaya ihtiyaç olduğunu ifade etmişlerdir. Bununla birlikte, gebeliğin son aşamasında yalnızca kısa süreli bir sıcaklık stresinin buzağıların sağlığı, büyümesi ve performansı üzerinde yoğun etkileri olabileceği ve bu hayvanlar üzerinde uzun vadeli bir etki yaratabileceği belirtilmektedir (Laporta ve ark., 2017).

İklim değişikliğinin neden olduğu potansiyel değişiklikler arasında patojenler ve vektörler de yer almaktadır. Mera kaynaklı nematod ve trematod enfeksiyonlarının yaygınlığı ve dağılımı buna örnek olarak verilmektedir. Bunlar, iklim değişikliğinin etkileriyle birlikte epidemiyoloji, mevsimsellik ve coğrafi dağılımdaki değişiklikleri işaret etmektedir (Morgan ve ark., 2013). Parazit ve vektör epidemiyolojisinde oluşacak değişiklikler bölgeye ve mevsime bağlı yenilikçi çözümler gerektirmektedir. Daha iyi bir bölgesel uyum stratejisinin geliştirilmesi için Avrupa genelinde iklim kaynaklı değişikliklerin sistematik olarak izlenmesi önerilmektedir (Charlier ve ark., 2016). Bu tür stratejilerin iç veya dış mekân yetiştiriciliği, yeni teşhis araçlarının kullanımı, yenilikçi kontrol yaklaşımları, sürdürülebilir ilaç kullanımı ve kontrol uygulamalarının entegrasyonu gibi belirli yönetim stratejilerini içermesi gerekmektedir (Vercruysse ve ark., 2018).

İklim değişikliği, vektörün ve virüsün hem dağılımını hem de popülasyon dinamiklerini etkilemektedir. Patojenler ve vektörlerle başa çıkmak için iklim değişikliklerinin etkilerini hafifletmek amacıyla yetiştiricilik sistemine uygun stratejiler oluşturulmalı ve yönetimsel önlemler alınmalıdır. Bu amaçlarla yetiştiricilik sistemine göre yeni teşhis araçlarının kullanımı, etkili ilaç kullanımı ve ilaçlama, iklim, bölge ve patojenlere ait bilgileri içeren veri tabanlarının geliştirilmesi, kontrol stratejilerinin oluşturulması gibi yöntemler kullanılabilir. Hayvancılık için hafifletme ve uyum önlemlerine odaklanılmasının iklim değişikliğiyle ilişkili hastalıkların etkilerini en aza indirilebileceği ifade edilmektedir (Bett ve ark., 2017; Vercruysse ve ark., 2018).

Sıcaklık stresi, gün içindeki aktivitelerde azalma veya değişiklikler, su alımının artması, yem alımının azalması veya günün daha soğuk zamanlarına kayması gibi davranışsal değişikliklerle tespit edilebilir (Cook ve ark., 2007; Ammer ve ark., 2017). Allen ve ark. (2015), sıcaklık stresi yaşayan süt sığırlarında ayakta durma ve yatma davranışında değişikliklerin ve östrus sinyallerinin azalması gibi etkilerin görülebileceğini belirtmiştir. Heinicke ve ark. (2019), sıcaklık stresinin süt sığırlarının aktivitesinde azalmaya yol açtığını, erken laktasyondaki hayvanların ise geç laktasyondaki ineklere göre daha az duyarlı olduğunu ortaya koymuştur. Ayrıca inekle ilgili bireysel faktörler olabileceğini de eklemişlerdir. Allen ve ark. (2015), ayakta durmanın ineklerin vücutlarının soğumasına yardımcı olabileceğini ve bu nedenle sıcaklık stresi yaşayan ineklerde ayakta durmanın arttığını, bu durumunda daha uzun yatma sürelerine ihtiyaç olan zamanlarda süt üretimini etkileyebileceğini öne sürmüşlerdir.

YEM VE SÜT İNEĞİ BESLENMESİ

İklim değişikliği senaryosu altında meraların verimliliği ve besin değeri tahmini için çeşitli modeller bulunduğu ifade edilmiştir (Ma ve ark., 2015). Otlatma mevsiminin süresi ile iklim değişikliği arasında pozitif bir ilişki bulunmaktadır (Phelan ve ark., 2016).

İklim değişikliğine bağlı olarak (özellikle kuzeyde) yem veriminin artacağı varsayılmaktadır; ancak suyun mevcudiyetine bağlı olarak yemin kalitesi değişiklik gösterecektir. Craine ve ark. (2010), iklim koşullarının yemdeki protein ve enerji mevcudiyeti üzerindeki etkilerini tahmin etmek için sığır dışkı örneklerini analiz etmişlerdir. Sıcaklıkların daha yüksek olduğu ve yağışların daha az yaşandığı bölgelerde yemlerde

sindirilebilir organik maddelerin azaldığını bulmuşlardır. Sıcaklık stresinin etkilerinin yanı sıra özellikle yüksek süt verimine sahip olan hayvanlarda yem tüketiminin fazla olması ek bir ısı yükü meydana getirmektedir. Yem tüketimi sonucu ortaya çıkacak olan etkilerin derecesi bölgenin iklimine ve yetiştiricilik sistemine göre değişiklik göstermektedir (Gauly ve Amber, 2020). Bu etkilerin azaltılması için meraların değişen iklim koşullarına uyum sağlayabilecek dayanıklı türlere ihtiyacı bulunmaktadır (Gauly ve ark., 2013). Bu amaçla daha derine kök salan baklagillerin kullanılması ve diğer türler için mevcut olmayan suyun değerlendirilmesi sağlanarak otlakların su kullanımı geliştirebilir (Chen ve ark., 2007; Perring ve ark., 2010). Yetiştirme stratejilerinin yanı sıra, otlakların yönetimi (kesim zamanı, gübre türü, otlatma uzunluğu) yem üretimi üzerindeki iklimsel etkilerin üstesinden gelmek için gerekli seçenekleri sağlayabilir (Holden ve ark., 2008). Meraların sulanması da verimi artıracaktır ancak su mevcudiyetindeki kısıtlamalar nedeniyle bu seçenek sınırlı kalmaktadır (Gauly ve Amber, 2020).

Yem katkı maddelerinin sıcaklık stresiyle başa çıkma yeteneğini geliştirmeye yönelik araştırmalar yapılmıştır. Zimbelman ve ark. (2010), rumen korumalı niasin ile beslenen ineklerin orta derecede ısı yükü altında daha düşük rektal ve vajinal sıcaklıklara sahip olduğunu göstermiştir. Wang ve ark. (2010), sıcaklık stresi sırasında tamamlayıcı doymuş yağ asitleri (SFA) ile beslenmenin günün en sıcak saatlerinde vücut ısısını düşürdüğünü ve süt verimini arttırdığını belirtmiştir. Bu etkinin, fermente edilebilir karbonhidratların tamamlayıcı SFA ile değiştirilmesi sonucu metabolik ısı gelişiminin azalmasıyla gerçekleştiği kabul edilmektedir (Gauly ve Amber, 2020). Dolayısıyla sıcaklık stresi ile başa çıkmak için yem katkı maddelerinin de alternatif bir yöntem olarak kullanılabileceği düşünülmektedir.

İKLİM DEĞİŞİKLİĞİ VE SÜT HAYVANCILIĞI

Sıcak günlerin yoğun olduğu dönemlerde süt hayvanı işletmelerinde özellikle yüksek verimli sürülerin yönetilmesi oldukça zordur. Sürü yönetim yöntemlerinde, soğutma teknikleri gibi yapısal değişiklikleri içeren seçenekler de mevcuttur. Örneğin, sıcaklık stresini düşürmek için yeterli gölgenin sağlanması, beslenme zamanlarının yönetimi gibi seçenekler kullanılabilir (Kendall ve ark., 2007; Legrand ve ark., 2009). Beslenme zamanlarında yapılacak olan değişiklikler (akşam, gece veya sabahın erken saatlerine, daha serin dönemlere geçilmesi) yüksek ortam sıcaklıklarında ısı yükünü düşürebilir (Nikkhah ve ark., 2011). Ominski ve ark. (2002), bu durumun, sıcaklık stresine maruz kalan süt sığırlarının vajinal sıcaklığını, yem alımını ve performansını etkilemediğini ifade etmiştir.

Süt sığırcılığı işletmelerinde sıklıkla kullanılan soğutma sistemleri fanlar, misterler, sprinkler ve soğutulmuş su yataklarıdır. Bunlara ek olarak yapılabilecek değişiklikler arasında tünel havalandırması gibi yeni teknolojiler yer almaktadır (Calegari ve ark., 2012). Süt sığırlarında sıcaklık stresinin azaltılması için verimli soğutma sistemlerinin kullanılması gerekmektedir. Bu amaçla kullanılabilecek diğer bir seçenek ise ahırdaki fanlar tarafından desteklenerek buharlaştırılan suyun kısa süreli püskürtülmesidir. Benzer sistemler dünya çapında özellikle sıcak bölgelerde yaygın olarak kullanılmaktadır. Kendall ve ark. (2007), üç farklı soğutma sisteminin (gölge, sprinkler ve gölge+sprinkler kombinasyonu) verimliliğini karşılaştırmıştır. Gölge+sprinkler kombinasyonunun solunum hızını %67 oranında azalttığını, sadece sprinklerin kullanılmasının (%60) sadece gölge sağlanmasından (%30) daha etkili olduğunu bulmuşlardır. Avendaño-Reyes ve ark. (2010), sıcak koşullarda soğutma süresini ve yoğunluğunu değiştirerek üç farklı yöntemi karşılaştırarak, daha iyi bir sonuca ulaşılması için soğutma süresinin uzatılması gerektiğini öne sürmüştür. Ayrıca, yağmurlama ve havalandırmanın birlikte kullanıldığı günlük soğutma periyotlarının daha sık olmasının soğutmanın etkisini arttığını da eklemişlerdir. Honig ve ark. (2016), sıcaklık stresi altındaki süt inekleri için soğutma yönetimlerinin kullanılmasının üreme performansı, yumurtalık fonksiyonları, östrus döngüsü uzunluğu ve genel doğurganlık üzerinde olumlu etkileri olduğunu belirtmişlerdir. Yaz aylarında ineklerin merada ısı yüküne maruz kalmasından sonra soğutma kapasitesi açısından tek başına gölge sağlanması sprinkler kullanımına göre daha az verimlidir. Ancak ineklerin tercihi dikkate alındığında ineklerin çoğunun (%65) sprinkler yerine gölgeyi seçtiği ifade edilmiştir (Schütz ve ark., 2011). Gölge sağlanmasının sıcaklığı azaltmasının yanı sıra, ısı yükü üzerine olan asıl etkisi güneş ışınlarının hayvanlara daha az temas etmesidir. Van Laer ve ark. (2015), gölgenin hayvanların performansı üzerinde olumlu etkileri olduğunu belirtmiştir.

SONUÇ VE ÖNERİLER

İklim değişikliğinin süt sığırı yetiştiriciliği üzerinde halihazırda önemli etkileri olmuştur ve bundan sonra da olmaya devam edecektir. Bu etkiler hem doğrudan hem de dolaylı olmaktadır. Süt sığırı yetiştiriciliği üzerindeki etkiler; yemin, suyun bulunabilirliği ve kalitesi, sağlık ve performans üzerindeki etkiler, hastalık ve vektörlerin yayılması üzerindeki etkiler olarak sınıflandırılabilir. Bu durum, üretim seviyesinde daha yüksek ölüm oranlarına, bağışıklık fonksiyonlarının bozulmasına, bulaşıcı hastalıkların daha fazla yayılmasına, üreme bozukluklarına, yem alımında ve büyümede değişikliklere, özellikle yüksek verimli süt sığırlarında veriminin azalmasına yol açar. Sonuç olarak belirtilen etmenlerin hepsi süt sığırı yetiştiriciliğinde ekonomik açıdan tamamıyla dezavantajlara neden olacaktır. Bu nedenle, uzun vadeli çözümler için hayvancılık sistemleri, yönetim, beslenme ve sağlığın yanı sıra bitki ve hayvan ıslahını da içeren iklim değişikliklerinin süt sığırları üzerindeki etkilerini azaltabilecek uyum stratejilerinin geliştirilmesine yönelik temel bir ihtiyaç bulunmaktadır.

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"**Küresel İklim Değişiklikleri ve Süt Sığırı Yetiştiriciliği**" başlıklı çalışmanın yazım sürecinde bilimsel kurallara, etik ve alıntı kurallarına uyulmuş; toplanan veriler üzerinde herhangi bir tahrifat yapılmamış ve bu çalışma herhangi başka bir akademik yayın ortamına değerlendirme için gönderilmemiştir. Bu araştırma doküman analizi ve betimsel incelemeye dayalı olarak yapıldığından etik kurul kararı zorunluluğu bulunmamaktadır.

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Review Article

Under Long-Term Agricultural Systems, the Role of Mycorrhizae in Climate Change and Food Security

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ABSTRACT

Over the past 100 years, the rapid growth in population from 2 billion to 8 billion has significantly impacted the environment and climate change. In addition, food consumption has skyrocketed, and there are widespread worries about global food security. Due to inadequate soil and plant management techniques, including high soil tillage, chemical fertilizers, inappropriate irrigation, and genetically engineered crops, this spike has made it more difficult to guarantee food security for everyone on the planet. These actions have resulted in societal unrest, climatic change, and land degradation. With organic carbon mineralization, more CO2 is released into the atmosphere because of atmospheric heating and climate change. Long-term greenhouse gasses released into the atmosphere cause global climate change. Increasing climate changes and the inefficiency of soil productivity result in the natural effects of the rhizosphere on plant growth and food security. One of the most effective mechanisms of the rhizosphere is mycorrhizal fungi, which are injured microorganisms. Frequently disregarded mycorrhizal fungi present a potential solution. While sequestering carbon from the atmosphere, they can increase agricultural yields, plant health, and soil fertility. For sustainable agriculture and environmental preservation, it is essential to understand and take advantage of the potential of mycorrhizal fungi. A crucial area for study and practical application is the function of mycorrhizal fungi in reducing these difficulties and enhancing food security. Considering rising environmental challenges, understanding their contributions and researching their relationships may help create a more stable and secure global food system..

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INTRODUCTION

The present Situation of Our Food Security Problem

In the last 90 years, the world population has increased from 2 billion to 8 billion (Figure 1). These 6 billion had a significant influence on the environment and climate change. For the food security of 8 billion people, poor soil and plant management, such as heavy soil tillage, chemical fertilizers/persists, unsuitable irrigation, and genetically modified plants and seeds, causes soil degradation, climate change, and unsafe social life.

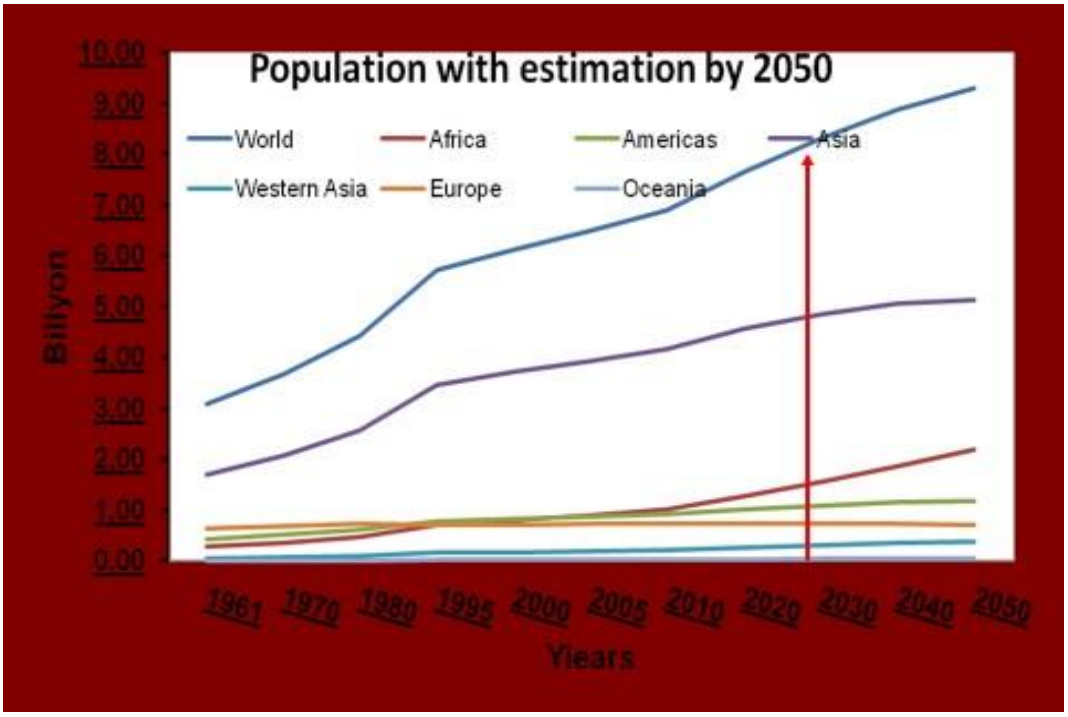

Figure 1. *World population growth (FAOSTAT, 2023)*

In the short history of humanity, and especially after the industrial revolution in the last 100 years, nature has been heavily interfered with by human activities. The excessive production– consumption relationship for the various needs of billions of people has reduced the biological budget capacity of nature and changed the balance of greenhouse gasses in the atmosphere. The climate crisis has begun to threaten our lives, especially the terrestrial ecosystem, just as we had in the past.

Global population growth and mismanagement of soil and plant resources have resulted in soil degradation, climate change, and a threat to social well-being. The industrial revolution has further aggravated the situation by disrupting the balance of greenhouse gasses in the atmosphere and reducing the capacity of nature's biological budget.

What have we created for food security?

Heavy fertilizers have been widely employed in plant production in traditional agricultural systems since the turn of the century. Nevertheless, many traditional field-cropping methods have come under fire for being unsustainable because they worsen the ecosystem.

Critics criticize the current global management and agriculture production system. The production system has also come under fire in several ways. One is that the chemicals used have a direct impact on human health as they travel up the food chain from soil to people. The other is the decrease in chemical fertilizer sources. What causes climate change and how?

What connection does it have to farming? primarily population expansion, urbanization, and rising food prices. If asked, "Who governs nature's life today?" Who is the world's strongest? Developed nations or powerful leaders? No! The Covid-19 virus, one of the microscopic bacteria that we all know are invisible, first affected our lives three years ago. Approximately 7-8 million people died, and for a protracted period, we were in despair.

Do microbes play a role in nature and have any other effects on how we live? If so, what animals?

Naturally, they have been for a few million years. They existed, but we were unaware of them. To guarantee food security, reduce climate change, and encourage biodiversity preservation, it is essential to understand the role of mycorrhizal fungi in carbon sequestration, soil fertility, and plant health. By using their potential, native management techniques can produce more resilient agricultural systems and a better environment.
Looking back, we can see that these intangible beings contain highly diligent life forms that have aided the sustainability of our planet's natural environment and our way of life (Redecker, Szaro, Bowman, and Bruns, 2001).

How much do we know about the relationship between climate change and microorganisms?
The atmospheric CO_2 content has already increased from 280 to 414 mg L^1 since the Industrial Revolution. The increase in yearly means a 2.08 ppm yr^{-1} average growth rate over the previous ten years. Climate change significantly impacts agriculture, altering crop production systems by altering temperature, rainfall patterns, and fertilizer availability. Mycorrhizal fungi are essential for sustainable agriculture because they improve plant growth, nutrient uptake, and water use efficiency.
At present, the biggest aim, again climate change is to maintain atmospheric CO_2 and transfer it into the soil (Figure 2). Without plants, mycorrhizae are not possible

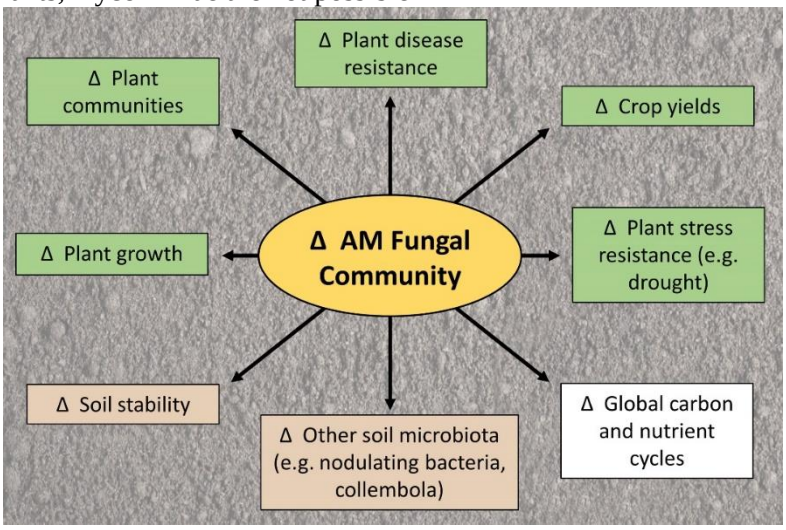

Figure 2. *Potential consequences of changes in AM fungal communities due to global change (Cotton, 2018).*

Perhaps we have paid little attention to the role and function of mycorrhiza in nature and human life. The relationship between human nutrition and soil and atmosphere through plants seems to have been neglected.
How have we neglected the relationship between mycorrhiza and human life?
As indicated by Field, Daniell, Johnson, and Helgason (2020), only the edible mushroom industry is worth 42 billion dollars annually. Orchid mycorrhiza also has more benefits for food and health.
Finally, the potential consequences of changes in AM fungal communities due to global change are clear. Mycorrhizae act between soil plants and the atmosphere in several ways to survive and contribute to sustainable food security.
Thus far, our knowledge about mycorrhizae does not reflect the contribution of mycorrhizae to ecosystem services. Wrage, Chapuis-Lardy, and Isselstein (2010) reported that global climate change influences soil P availability. In addition, it is widely known that plants' mycorrhizal hyphae acquire 75% of the P. Additionally; mycorrhiza inoculation is reported to increase the root surface by 140 times. The majority of mycorrhizal research has been conducted in forestry, agriculture, and plant science. Perhaps we have paid little attention to the role of mycorrhiza in nature and human life. The relationship between human nutrition and soil and atmosphere through plants seems to have been neglected.

These complex symbiotic relationships between fungi, plants, and the rest of life are sustained by a complex underground food exchange web that is invisible to the naked eye and forms the basis of virtually all land-based life.
Effectively using mycorrhizal fungi in field settings is difficult. To maximize mycorrhizal spore quality and effectiveness for sustainable plant growth and development, these issues must be addressed.

The world's first and oldest symbiosis (Figure 3) is mycorrhizal fungi, which hold great promise for resolving our current environmental and food security problems. It is impossible to undervalue their contribution to ecosystem resilience, nitrogen cycling, and carbon sequestration. We can strive toward a more sustainable future for agriculture and the planet as a whole by prioritizing the preservation and use of mycorrhizal fungi. It seems that we know a lot about mycorrhizae, but not about their role in climate change. It seems that there is still much that we do not know. To me, we do know the role of mycorrhizae on plant nutrient uptake and healthy plant growth. However, we do not exactly know the function and link of mycorrhizae between soil and their mutually beneficial effects on carbon capture. Because plants and/or mycorrhizae know the soil phosphorus and other nutrient concentrations, they make mycorrhiza efficient. How do they know? We are still not aware of these mechanisms. Mutual chemical and biological usefulness is important for ecosystem sustainability. In addition, mycorrhizal fungi support the health of native ecosystems, the resilience of forests, and ecosystem functioning. They make it easier for plants to transport organic carbon-based molecules to their fungal symbionts, enhancing mutualistic relationships and fostering biodiversity.

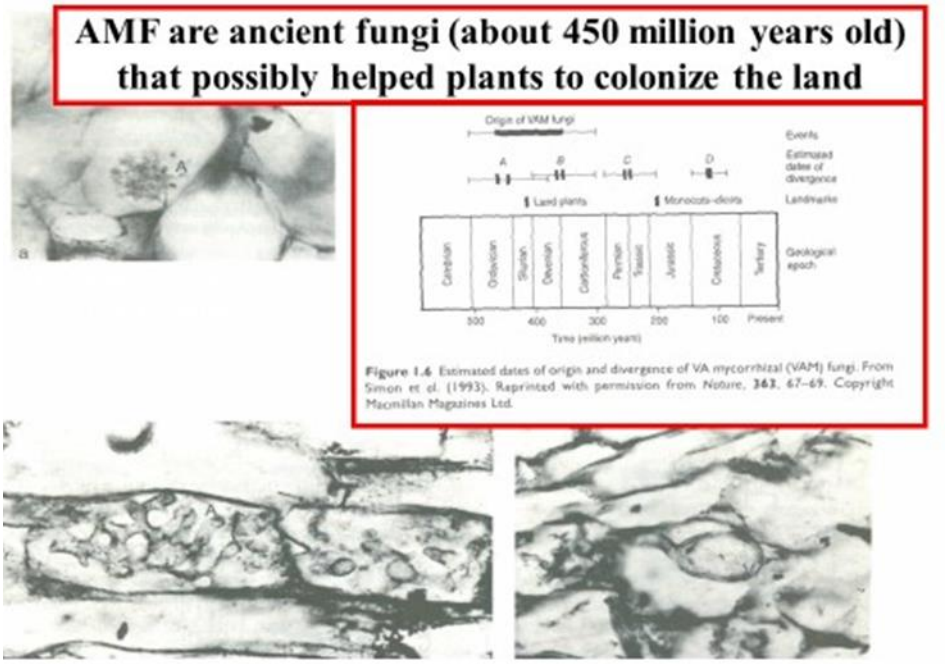

Figure 3. *The oldest mycorrhizal fossil (Simon, Bousquet, Lévesque, and Lalonde, 1993)*

Publication on Mycorrhizae and Climate Change

The question is, because microorganisms exist in our lives and undertake dreadful tasks. What then is the problem we are experiencing now? What is the solution?

How broad and deep do we know about climate change or the climate crisis?
How much basic knowledge do we have about the effects of mycorrhiza on plants and ecosystems?
How much do we know about the effects of mycorrhizal and climate changes on soil– plant and ecosystem functioning?
It appears that we know a lot about the role of mycorrhizae. However, what we still do not know is more than our knowledge. Recently, the number of papers published on the mycorrhizae area is increasing. Since 1990, 35572 papers were published with mycorrhizae on WOS (Figure 4). Most of the work was done on mycorrhizae's role in agriculture, and most of the work was done on phosphorus uptake and bioavailability (WOS 2023).

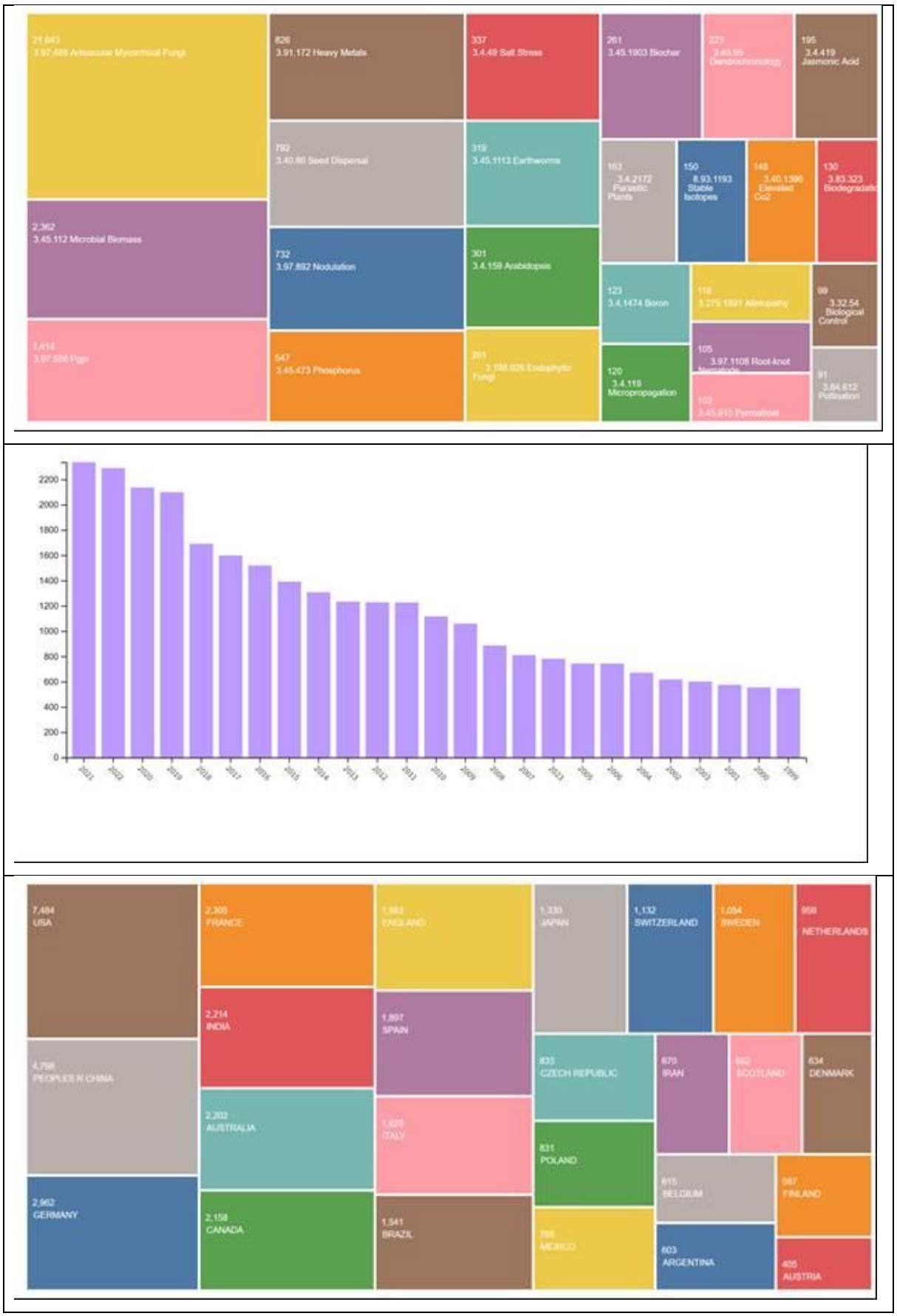

Figure 4. *Research papers on climate change and mycorrhizae works (data were gathered from WOS)*

240 papers on water resources have been published and fewer on global warming. Additionally, publications on mycorrhiza and climate change were published in 1845. Only 148 citations were done on elevated CO_2. Mycorrhizae are mostly searched in developed countries. Not in Africa and poor countries.

In the last 90 years, the world's population has exponentially increased from 2 billion to 8 billion, putting unprecedented pressure on Earth's natural resources, especially for food security. In addition, global plant temperatures are set to rise >1.5°C by the end of the 21st Century (IPCC, 2014). The temperature increase is expected to affect soil macro- and microorganisms. The effects of CO_2 and/or temperature on plant growth and fungal functioning could have influenced both the capacity of plants to allocate carbon to AM fungi, which increased/inhibited the nutritional or other benefits plants obtain from the symbiosis (Duarte and Maherali, 2023).

Recently, increasing research and publications have been conducted on CO_2 fixation through photosynthesis from the atmosphere to the roots and soil. Many studies have shown that elevated atmospheric CO_2 levels positively influence the abundance of mycorrhizae (Compant, van der Heijden, and Sessitsch, 2010). Mycorrhizae play a key role in CO_2 fixation in the atmosphere. It is not sufficient to fix CO_2 through photosynthesis in plant tissue. It is also important to store carbon long-term in plant tissue and allocate it to the plant roots. It is also necessary to keep more organic carbon in special positions in the soil, such as macro- and microstructures. Plant roots play a critical terminal role in leaking carbohydrates to the rhizosphere, where many microorganisms collaborate, challenge, and compete with each other (Figure 5). Some beneficial microorganisms enter the root systems of their hosts as part of an entophytic lifestyle. Thus, organisms have a significant contribution not only to host plants but also to soil development. Mycorrhizae and plant roots collaborate to create strong macro- and microstructures to keep C in side aggregates. Since 1975, several researchers have investigated the effect of carbon fixation and allocation on roots. So far, it is known that 22% of the carbohydrate leaked into the rhizosphere.

A crucial part of carbon sequestration is played by mycorrhizal fungi, which have been sustaining life on Earth for millions of years. They do this by absorbing carbon dioxide from the air and transferring it to the soil via a sophisticated underground network. This procedure reduces CO_2 emissions and fights climate change. In a study published recently in Current Biology, they estimated that mycorrhizal fungi in nature release 13.12 gig tons of carbon dioxide equivalents ("CO2e") into soil ecosystems each year by capturing carbon from the atmosphere and transferring it to the soil. This equates to approximately 36% of annual global fossil fuel emissions. This shows that mycorrhizal fungi play a vital role in combating climate change.

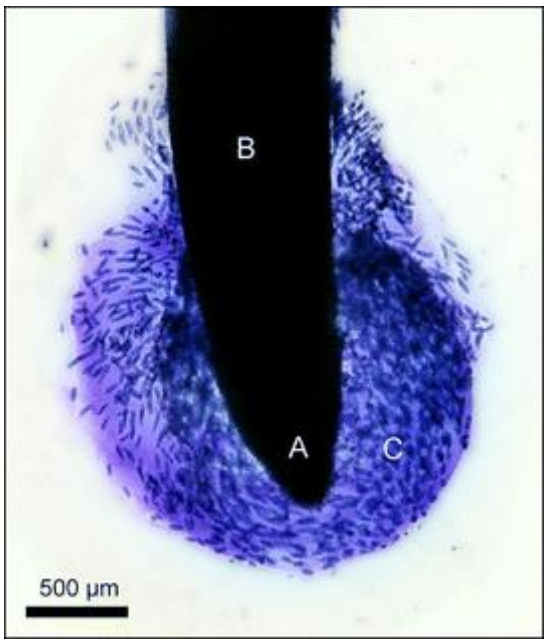

Figure 5. *Light microscopy image showing mucilage (blue halo surrounding the root) and border cell production in a Zea mays L. root tip (Jones, Nguyen, and Finlay, 2009).*

Organisms produce most of the mucilage as well. In addition, there are positive correlations between root exudate organic acids and total microbes, fungi, Azotobacter, PSB, and PSF (Sumarsih, Nugroho, and Widyastuti, 2017).

The invention and use of sciences and technologies, including insecticides, nitrogen- and phosphorus-rich fertilizers, and improvements in plant breeding and genetic technologies, led to a huge increase in agricultural production following the "green revelation". However, in the last 20 years, many key crop yields have plateaued (Thirkell, Charters, Elliott, Sait, and Field, 2017). It is estimated that by 2050, the need to increase agricultural productivity by at least 70% can be met using sustainable agricultural management. Because of environmental pollution problems, the role of soil biodiversity, particularly arbuscular mycorrhizal (AM) fungi, will become more important. More importantly, because of severe extreme climate events, future agricultural productivity needs to become more resistant and resilient, and agriculture production and management needs to become climate-smart (Lipper et al., 2014).

With the population increase and increasing the intention of climate change on plant growth and soil quality is a serious measurement for food security (Ortas, 2022). Due to mismanagement of agriculture, forestry, and other land uses, global atmospheric gas emissions increased by nearly 80%, and projections suggest continual increases from 1940 to the present. This sustainable future is under pressure from climate change.

Crop production is sensitive to climate change. Climate change may affect crop production systems in several ways, including direct and indirect effects such as changes in rainfall leading to drought or flooding, warmer, or cooler temperatures leading to changes in the length of the growing season of plant species. In addition, climate change may significantly affect the nutritional properties of many crops such as maize, wheat, soybeans, and rice. According to Elbehri (2015), under high conditions of elevated CO2 levels, the concentrations of minerals in wheat, rice, and soybeans are lower by up to 8%. Approximately 13% of anthropogenic greenhouse gas emissions are attributed to agricultural practices (Metz, Davidson, Bosch, Dave, and Meyer, 2007). Since crop and food production are sensitive to climate change, urgent mitigation is required. The effect of climate change on agriculture is related to adverse growing conditions such as drought and temperature increases. On the other hand, crop production can reduce the negative effects of CO2 pressure on climate change. Improving crop and soil management practices can increase carbon storage in plants and later in the soil.

Since increasing CO_2 concentrations in the atmosphere have a direct effect on soil warming or drought stress, they also have indirect effects on plant-associated fungi (Augé, 2001). Poorter and Navas (2003) reported that elevated CO_2 levels enhanced the aboveground biomass of C3 plants on average by 45%, whereas C4 plants showed an increase in their biomass production by only 12%. In previous studies, it has been shown that with ambient CO_2 (350 mL L-1) rhizosphere organisms are grown, and as a result, C allocation increases to the root area, external hyphae (Rillig and Allen, 1999), and internal hyphae of AMF. In addition, there is a contrasting result showing no response to CO_2 effects on rhizosphere growth. Compant et al. (2010) indicated that distinct mycorrhizal strains, plant genotypes, or specific associations respond differently to altered environmental conditions. In our experience under field conditions, mycorrhizal responses are diverse.

Root colonization is facilitated by rising temperatures and CO_2 levels, which are often increased. AMF could consequently promote plant growth and nutrient uptake (Figure 6).

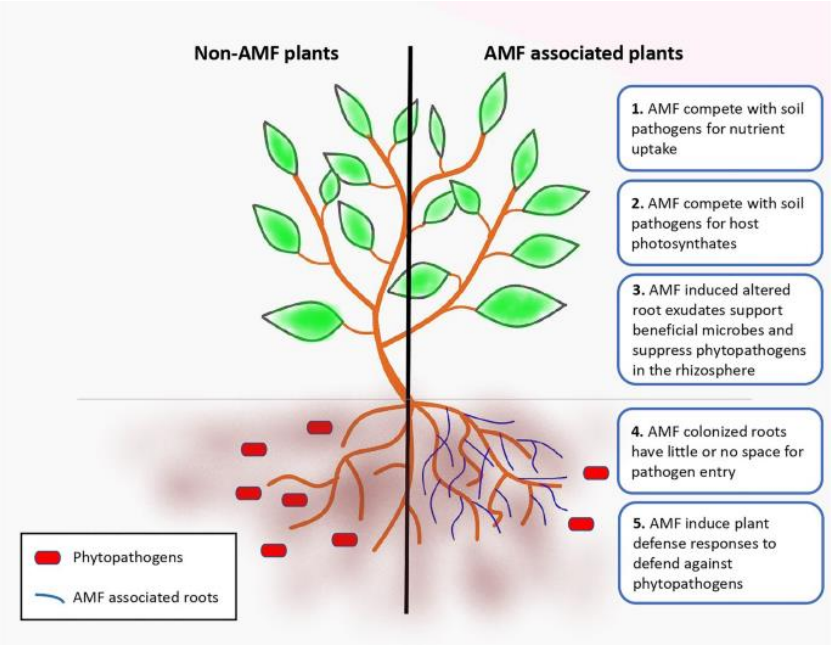

Figure 6. *Effect of mycorrhizae on plant growth under phytopathogen disease (Augé, 2001)*

Most plant species (approximately 90% of plants) are growth-promoting microorganisms that colonize the rhizosphere, which is influenced by root exudates and microorganisms (Smith and Read, 2010). Some beneficial microorganisms enter the root systems of their hosts and enhance their beneficial effects.

AM fungi are considered a crucial biotechnological tool in crop production (Sitoe and Dames, 2022). Soil microorganisms, such as mycorrhizal fungi and Rhizobium bacteria, have an important influence on soil fertility and plant growth/health. Mycorrhizal fungi such as endophytes and PGPB have been applied as biocontrol agents, bio fertilizers, and/or phytostimulators in agriculture (Lugtenberg and Kamilova, 2009).

Soil and crop management, soil types, and crop species play a significant role in mycorrhizae diversity and effectiveness. AM diversity significantly contributes to mineral nutrient uptake (Ortas and Ustuner, 2014) and water use efficiency (Brussaard, De Ruiter, and Brown, 2007). AM fungi specifically compete for nutrients and water uptake , thereby reducing nutrients for other microbes such as decomposers (Sosa-Hernández, Leifheit, Ingraffia, and Rillig, 2019). Mycorrhizae and other beneficial soil organisms have resilience against abiotic disturbances and stress factors. In agroecosystems, the relationships between management, plant and soil biodiversity, soil structure, and nutrient and water use efficiencies were investigated by Brussaard et al. (2007).

Mycorrhizae inoculated with most plants transfer organic carbon-based compounds (e.g., sugars and lipids) to their fungal symbionts. As a symbiosis, the relationship between mycorrhizal fungi and plant roots is usually considered to be a mutualistic interaction. Mycorrhizal fungi are essential in the formation and functioning of sustainable global ecosystems (Field et al., 2020). It has great potential for the future of plants, animals, and the planet in terms of food security and climate change (Figure 7).

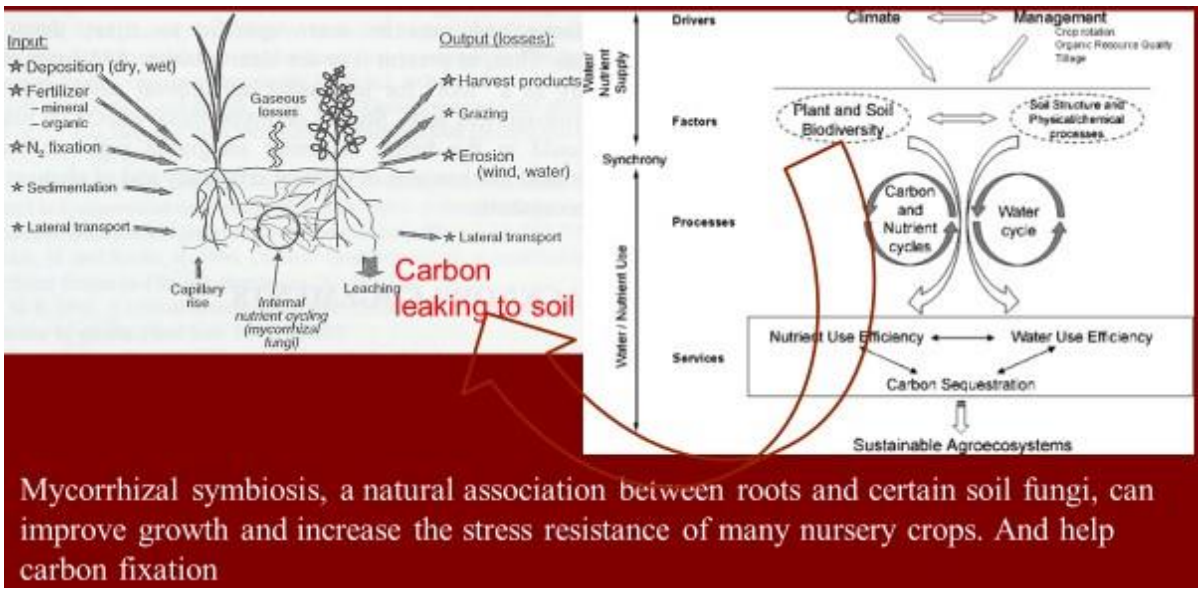

Figure 7. *Underground nutrient and carbon exchange mechanisms (Ortas, 2022)*

Arbuscular Mycorrhizae Role in Plant Restoration in Native Ecosystems

Due to increasing climate changes, it is expected that important changes will occur in the natural vegetation. For example, some plant species may migrate to other areas where they will find new habitats, and some of them may disappear. Due to this situation, it is expected that the Mediterranean areas, especially in Central Anatolia and Southern Anatolia, will expand under drought and soil degradation, and pasture and natural vegetation areas will decrease. As a result, the reduction of the natural mycorrhizal flora in the rhizosphere zone of the plants in question may delay the development and adaptation of new plants. There is high plant biodiversity in southern Turkey due to the floristic mixing of the warm temperate Mediterranean climate.

Mycorrhiza have several positive effects on soil and plant development.

Carbon (C) and nitrogen sequestration and mineral nutrient cycling are the many significant ecosystem services provided by plant and mycorrhizal symbiosis. In terms of global climate change and the carbon cycle, mycorrhizal fungi play a critical role in carbon sequestration in soils. All plant species, especially the three plants, are major carbon sinks, and they play a vital role in mitigating the CO_2 gasses caused by climate change.

While the increased amount of CO_2 in the atmosphere increases the abundance and activity of mycorrhizal fungi, it increases the abundance of fungi in the case of increasing high temperature, but their activity in soil nutrient transfer to plants decreases. At that time, SOC can be out of the rhizosphere part of roots, which is essential for the mitigation of atmospheric CO_2. In drought and warmer conditions, mycorrhizal fungi can reduce plant stress and increase plant productivity. In European grassland communities, it has been reported that AM fungi stimulate soil respiration of pasture soil, leading to elevated CO_2 levels and temperature, with most carbon sequestered in belowground parts (Bahn et al., 2008).

Mycorrhizae contribute to soil nutrient cycling by enhancing plant mineral nitrogen uptake; increased nitrogen in the plant is more likely to demand more carbon fixation, leading to enhanced microbial development via increased root exudation(Ortas, 2019a). Since AM is competitive with other microorganisms for nutrients and water, in the absence of AM in the rhizosphere, higher rhizodeposition would stimulate microorganisms to stimulate SOM decomposition. According to (Bago, Pfeffer, and Shachar-Hill, 2000), AM fungi receive up to 20% of a plant's assimilates for their metabolism. After the extra radical mycelium forms the root, exudates can be released and make an important contribution to SOM. It has been reported by (Clemmensen et al., 2013) that in boreal forests, in subsoil, when root densities are high in deep horizons, up to 70% of soil C can be root-derived. Sosa-Hernández et al. (2019) indicated that AM mycelium can be a crucial pathway of C to the SOM pool (Figure 8) when mycelial exudes organic

compounds to soil parts more distant from the root system. The hyphae of mycorrhizal fungi play an important role in maintaining soil structure, holding soil particles together, increasing soil aggregation, and thus increasing soil pore size (Mardhiah, Caruso, Gurnell, and Rillig, 2016). Thus, keeping more carbon and water in aggregates is critical for soil fertility and plant growth. In addition, they indicated that soil loss can be explained by the combined effect of roots and AMF extra radical hyphae, and the unique effect of AMF hyphal length significantly reduced soil loss. As can be seen in the figure. AMF has an important influence on soil and plant parameters, which increase plant growth.

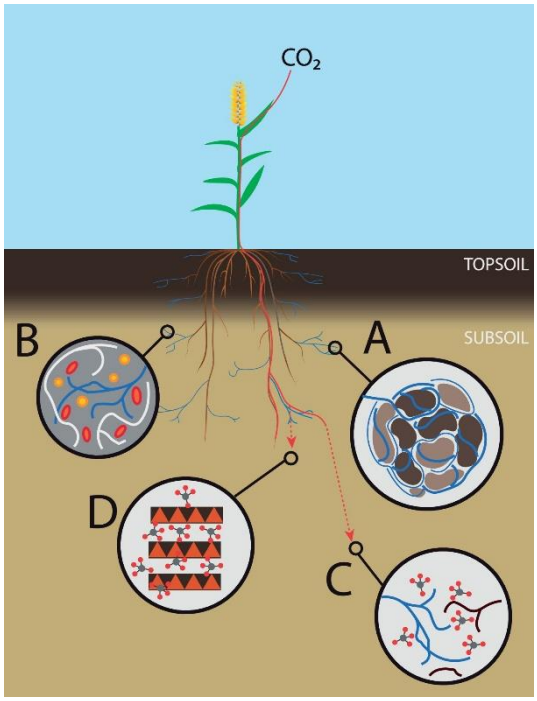

Figure 8. *Role of mycorrhizae hypha on soil development (Sosa-Hernández et al., 2019)*

Mycorrhizae's power of exploitation and management to facilitate a variety of sustainability programs in agriculture such as conservation and restoration, considerations that are particularly relevant during this time of global climate change and widespread depletion of natural resources. The role of soil biota, particularly arbuscular mycorrhizal (AM) fungi, in carbon sequestration and sustainable agriculture is of paramount importance. Orr, Rillig, and Jackson (2021) indicated that the anthropogenic stressors that are impacting biodiversity and ecosystem functioning worldwide can be physical, chemical, and biological.

Recent AM fungal research results showed that plant and fungi species may play a key facilitative role in belowground micro- and meso-organism community dynamics similar to those of a bioengineer. Mycorrhizosphere dynamics are more interesting. Wrage et al. (2010) indicated that increasing temperatures tend to increase the P mineralization of litter. Temperature increases by 5°C have been found to double the colonization of roots by mycorrhiza. In addition, it has been reported that nitrogen mineralization was enhanced by an average of 48% by temperature increases between 0.3°C and 6.0°C (Wrage et al., 2010). Larger N uptake may stimulate phosphatase exudation and plant P uptake. In the presence of AM fungi, phosphorus losses by 50% under both rainfall scenarios and nitrogen losses by 40% under high rainfall intensity were reduced (Martinez-Garcia, De Deyn, Pugnaire, Kothamasi, and van der Heijden, 2017). This means that the AM fungi reduced the nutrient leaching risk when rainfall intensity increased, which is essential for future climate change on nutrient management in soil. Also, this finding is important under climate change caused by increased rainfall AM fungi can enhance ecosystem resilience and reduce the negative impact of increased precipitation on nutrient losses.

Mycorrhizae symbionts act as a barrier to the absorption of heavy metals by plants and reduce root-to-shoot mineral translocation. The results of Amir, Lagrange, Hassaine, and Cavaloc (2013) indicate the potential of selected native AMF isolates from native areas for ecological restoration of such degraded ecosystems. The growth of many plants is tightly correlated with AM root colonization. Possibly for optimum growth and nutrient uptake, the plant is planning to have root exudate and demand mycorrhizal colonization (Figure 9).

Native microbial communities and mycorrhizal inoculation have a significant contribution to native plant succession against invasive species. The results of Wilson, Hickman, and Williamson (2012) indicate that the restoration of native AM fungal communities may be a fundamental consideration for the successful establishment of native grasses in invaded sites.

Soil and Crop Management with Mycorrhizae Development, Crop Production, and P Uptake

In general, heavy tillage breaks down the soil structure, and as a result, this extra radical hyphal network is disrupted, which can reduce the inoculation potential of the mycorrhizae spores (T. P. McGonigle, Miller, and Young, 1999). Also, because of the breakdown of the hyphal network, the absorptive abilities of the mycorrhizae hyphae can be reduced (T. P. McGonigle and Miller, 1999). Jansa et al. (2003) have shown that under long-term field conditions, soil tillage changes microbial activity and nutrient content of the soil. T.P. McGonigle, Evans, and Miller (1990) also reported that heavy tillage reduced root colonization of maize plants and reduced the P and Zn contents of shoot parts.

It is quite clear that mycorrhizae are an essential component of ecosystem biodiversity and sustainability. Mycorrhizae play a significant role in plant nutrition, water uptake and protection, and ecosystem services. The applications of mycorrhizal fungi in sustainable agriculture and forestry systems can make an additional contribution from nature to soil life. It is also important to manage soil organism, especially mycorrhizal fungi, which is a powerful tool to fix more CO_2 from the atmosphere to soil through plant leaves and roots. AM enhances the (SOC) pool, the development of the soil structure, and the transfer of atmospheric CO_2 to the soil through photosynthesis is a crucial strategy for mitigation of climate change effects. In general, there is a large difference between plant species in terms of mycorrhizal species inoculation and CO_2 fixation, which is dependent on the C3, C4, and photosynthesis systems.

The effect of mycorrhizal inoculation and indigenous mycorrhizae effectiveness is much greater on soil fertility, the effectiveness of spores, and the number of spores. There is a need to work more. A suitable soil-crop management system will help mitigate climate change and ensure safe food security.

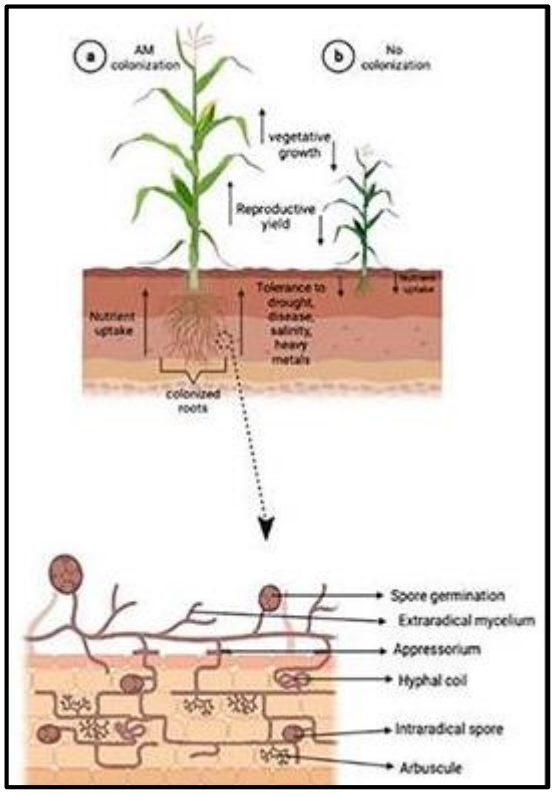

Figure 9. *Effect of AM fungi on stress factors and crop growth (Sitoe and Dames, 2022)*

Role of mycorrhizae fungi to tolerance to drought, temperature and salinity

Plant growth and soil quality are affected by environmental strass factors such as drought and salinity. Increasing temperatures caused by climate change increase drought and salinity issues in many regions. In many parts of world especially under the semi-arid climate conditions, because of miss managements of soil and plant, more and more arable land are getting under salt conditions (Ortas, Rafique, and Çekiç, 2021). A significant portion of plant species develop a tolerance to salinity and drought thanks in large part to AM fungi. The host plants' capacity to flourish in the face of stressors like drought is aided by AM fungus' capacity to utilize soil resources. Soluble salt accumulation in the rhizosphere can lead to decreased water potential (Li, George, Marschner, and Zhang, 1997) and, consequently, less water available for plant use. The biggest threat to food security arises when these salts are absorbed by plants growing in these conditions, as this can affect their physiological functions.

Mycorrhizal contributions to sustainability

Arbuscular mycorrhizal (AM) fungi were found in many native plant roots that grow in coastal southern Turkey. Most native species were grown under natural conditions of poor and salty soil conditions that depend on AM fungi. The symbiotic relationship between AM fungi species and native halophytic plants is important in the marginal soil ecosystem (Jayachandran and Fisher, 2008). In addition, it is useful for the restoration of native plants for healthy animal and human food quality. From viruses and fungi to big mammals, animal life is controlled by epicontinental conditions. Because most plant species are directly and/or indirectly affected by mycorrhizal inoculation, it is important to look at mycorrhizae in different ways.

Atmospheric CO_2 concentration increases (Cotton, 2018) and changing temperatures have been shown to affect the rate and quantities of carbon and mineral nutrients exchanged between mycorrhizae and plant species (Gavito, Schweiger, and Jakobsen, 2003). With climate change in our region, land degradation associated with unsustainable farming practices the crop yield does not increase, in those cases, it decreases. In the last 20 years, many plants' yields have plateaued despite increasing fertilizer and other inputs (Grassini, Eskridge, and Cassman, 2013).

Under climate change conditions, the stability of carbon largely depends on the interactions and balances between plants, mainly trees, and mycorrhizal fungi. CO_2 enrichment, temperature rise, increased N deposition, soil degradation, and biological diversity losses are the main drivers of climate change and have a significant impact on mycorrhizal functionality. Under climate change, mycorrhizae play an important role in the resilience and recovery of forest ecosystems. The physiological function of mycorrhiza-like symbioses is dependent on several abiotic and biotic factors (Field and Pressel, 2018).

Godfray et al. (2010) reported that there is significant potential to exploit the power of soil fungi in the production of food. If mycorrhiza spores are successfully applied, mycorrhizae could help reduce agricultural fertilizer inputs while maintaining and increasing crop yields. Under the most natural conditions, mycorrhizae inoculation has a competitive advantage over non-mycorrhizal plants (Chen, Arato, Borghi, Nouri, and Reinhardt, 2018).

How Much Carbon Transfers from Plant to Fungus?

Plant-to-fungus C transfer is a very important fundamental aspect of mycorrhizal partnerships, particularly in AM symbioses where the fungi, being obligate biotrophs, are entirely reliant on their host plants for organic C (Smith and Read, 2010). It has been reported that plants may direct up to 50% of their photosynthesis to their mycobionts in mycorrhizal partnerships (Soudzilovskaia et al., 2015). estimated that mycorrhiza symbioses alone annually contribute significantly to global carbon emissions of 5 billion tons. Previously (Douds, Johnson, and Koch, 1988) estimated that plants have transferred 4%–20% more photoassimilate to mycorrhizal root systems. Also recently, it has been indicated that AMF might also have an unappreciated role in plant host N nutrition. Since carbon and nitrogen control each other with a C: N ratio, it is important to focus on the subjects.

Under field conditions, the contribution of mycorrhiza to the mitigation of CO_2 emissions is important in several ways. The results show that under field conditions, mycorrhizae-inoculated seedlings such as pepper, melon, cucumber, and marrow produce up to 35 % yield increases in several horticultural plants (Ortas, 2019b). This means that mycorrhizal colonization fixed more atmospheric CO_2 than non-colonized ones. The biggest problem with using mycorrhizae under field conditions is the quality and effectiveness of mycorrhizae spores. Indigenous mycorrhizal management is important.

CONCLUSION

Due to factors including a fast-expanding population, poor management of soil and plant resources, and the negative effects of climate change, the existing level of food security is under increasing threat. Furthermore, the exponential increase in the world's population has increased the need for food production, putting unprecedented strain on the earth's natural resources. The environment and natural ecosystems have been considerably transformed and disrupted by human activities during the past century, particularly those connected to industrialization and agriculture.

Unsustainable agricultural methods, such as intensive soil tillage, improper irrigation, overuse of chemical fertilizers and pesticides, and reliance on genetically modified organisms and seeds, are major contributors to these problems. Soil deterioration and climate change are the results of these practices.

In this setting, the importance of mycorrhizal fungi in addressing food security and reducing climate change appears to be a crucial and frequently disregarded factor. Mycorrhizal fungi may promote soil fertility, boost plant health, boost agricultural yields, improve soil quality, and even store carbon from the environment. To achieve food security and environmental sustainability in a changing world, the potential of mycorrhizal fungi in agriculture and ecosystem management can be recognized and fully used.

However, there is still much that we do not fully comprehend regarding the intricate connections that exist between mycorrhizal fungi, plants, and the environment, particularly considering climate change. To create sustainable farming methods and guarantee food security despite environmental threats, research understanding these relationships is essential. A more resilient and secure global food system will only be possible with additional study and practical applications of this understanding.

CONFLICT OF INTEREST

The authors declare no conflict of interest in this study.

AUTHORS CONTRIBUTION

The author fully contributed to the manuscript.

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