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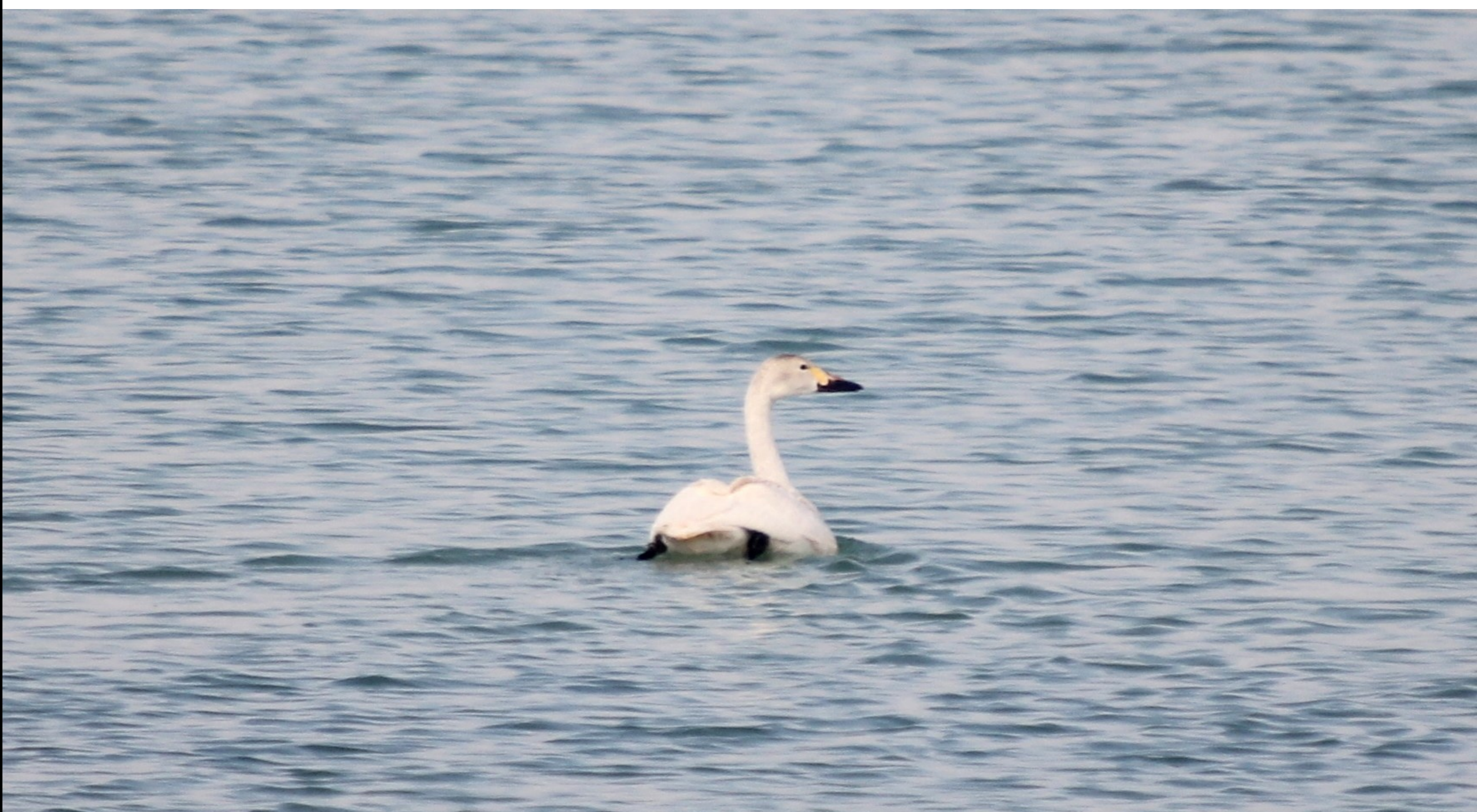

- Dependence structure analysis with copula GARCH method and for data set suitable copula selection
- A study on the distribution and population status of the Whooper Swan (cygnus cygnus l.1758) in the Van lake basin

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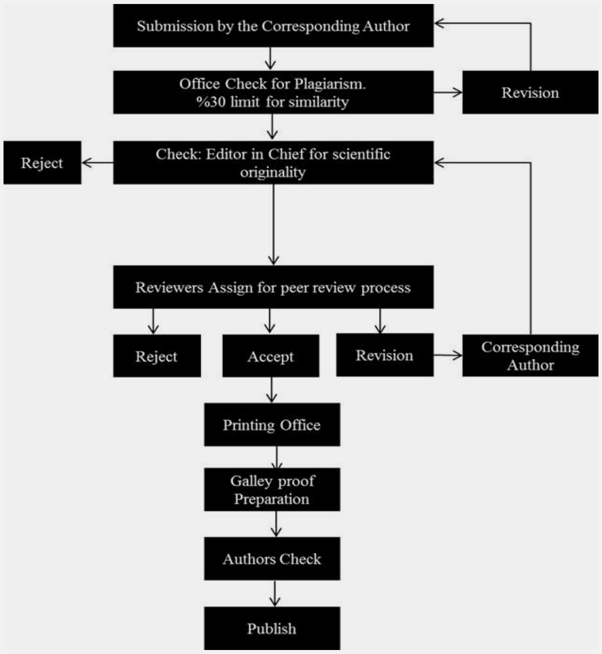

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Original Article

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Dependence structure analysis with copula GARCH method and for data set suitable copula selection

Ayse Metin Karakas[1]*

Abstract

Objective: Multivariate GARCH (MGARCH) models are forecasted under normality. In this study, for non-elliptically distributed the data set which are generated Weilbull distribution. Copula-based GARCH (Copula-GARCH) was used. The aim of the paper is to model GARCH for non-normal distributions using copulas.

Material and Methods: A two-step Copula-GARCH model to analyze the dependence structure of data sets was used. In the first step, we show data using univariate GARCH model to get standard residuals and construct marginal distributions. In this section GARCH (p,q) and GARCH (1,1) method are introduced. GARCH (1,1) method for data set was used for first step. In the second step, for dependence structures of the data sets were calculated Kendall Tau and Spearman Rho values which are nonparametric. Based on this method, parameters of copula are obtained.

Results: A clear advantage of the copula-based model is that it allows for maximum-likelihood estimation using all available data.

Conclusion: The aim of the method is basic to find the parameters that make the likelihood functions get its maximum value. With the help of the maximum-likelihood estimation method, for copula families obtain likelihood values. This values, Akaike information criteria (AIC) and Schwartz information criteria (SIC) are used to determine which copula supplies to suitability to the data set.

Key Words: Copula Function, GARCH method, Kendall Tau, Spearman Rho, Akaike information criteria, Schwartz information criteria.

1. Introduction

In the past years, the standard method of estimating dependence has been Pearson's correlation coefficient, which is based on the multivariate Gaussian distribution. However, as Fama (1963) noted, financial time series do not provide the assumption of normality. Embrechts, McNeil, and Straumann (1999) proved that Pearson's correlation coefficient is not sufficient to show the dependence between variables not belonging to the family of elliptical distributions. That is to say there was a need for the establishment of new methods to overcome the drawbacks of Person's correlation coefficient. Multivariate GARCH models formed such a status. The aim of this model is modeling of the conditional covariance and conditional correlation matrix.

Today, a commonly used second alternative can be found in the so called copulas introduced by Sklar (1959). The aim of this paper is to model GARCH for non-normal multivariate distributions using copulas. Copulas are defined functions that join one dimensional distribution functions together to form multivariate distribution functions by Sklar (1959).

There were very few practical applications of copulas. Nelsen (1999) gave definition of copula with mathematic perspective. Later applications of copulas were defined in finance Embrechts, P., A. McNeil and D. Straumann (2002).

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2. Material and Methods

2.1. GARCH Model

GARCH model was first founded by generalizing ARCH model by Bollerslev and Eagle (1986).The GARCH (p,q) includes p lags of the variances in the linear ARCH (q) conditional variance equation. The variance equation can be generalized

$$\sigma_t^2 = w + \sum_{j=1}^{q} \alpha_j \varepsilon_{t-j}^2 + \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2 \quad (1)$$

Another extension is the Generalized ARCH or GARCH model. The GARCH model adds lags of the variance, ht-p, to the standard ARCH. A GARCH (1, 1) method refers to the presence of a first-order autoregressive ARCH statement and a first-order moving average GARCH statement. For GARCH (p,q)

✓ ε_t is the error terms from the mean the equation. $\varepsilon_t = \sigma_t Z_t$, here, Z_t is separate stochastic piece and also Z_t is residual series, Z_t have zero mean identical and independent distribution, σ_t is a time dependent standard deviation.

✓ $\beta_i \geq 0, \alpha_j \geq 0$ and $\sum_{i=1}^{p} \beta_i + \sum_{j=1}^{q} \alpha_j < 1$.

✓ $\sum_{i=1}^{p} \beta_i \sigma_{t-i}^2$ is show GARCH statements, $\sum_{j=1}^{q} \alpha_j \sigma_{t-j}^2$ is show ARCH statements.

✓ The parameter of ARCH statements and GARCH statements submit the influence of ARCH effect (past innovation) and GARCH effect on the conditional variance. The rate of this effect to the coming periods respectively.

In general GARCH (1,1) is enough to use for this series [3,7,18].

2.2. Copula Theory

The copula is defined as a $C : [0,1]^2 \to [0,1]$ that ensures the limiting conditions

✓ $C(u,0) = C(0,u) = 0$ and $C(u,1) = C(1,u) = u, \forall u \in [0,1]$.

✓ $(u_1, u_2, v_1, v_2) \in [0,1]^4$, such that $u_1 \leq u_2, v_1 \leq v_2$

$$C(u_2, v_2) - C(u_2, v_1) - C(u_1, v_2) + C(u_1, v_1) \geq 0.$$

Ultimately, for twice differentiable and 2-increasing property can be replaced by the condition

$$c(u,v) = \frac{\partial^2 C(u,v)}{\partial u \partial v} \geq 0 \quad (2)$$

where $c(u,v)$ is the copula density. In the following, for n-uniform random $U_1, U_2, \ldots, U_n$ variables, the joint distribution function C is defined

$$C(u_1, u_2, \ldots, u_n, \theta) = P(U_1 \leq u_1, U_2 \leq u_2, \ldots U_n \leq u_n).$$

Here θ is dependence parameter [1,2,3,4,5,8,9,10,11].

2.2.1. Sklar Theorem

Let X and Y be random variables with continuous distribution functions F_X and F_Y, with $F_X(X)$ and $F_Y(Y)$ are uniformly distributed on the interval $[0,1]$. Then, there is a copula such that for all $x, y \in R$,

$$F_{XY}(X,Y) = C(F_X(X), F_Y(Y)) . \quad (3)$$

The copula C for (X,Y) is the joint distribution function for the pair $F_X(X)$, $F_Y(Y)$ provided F_X and F_Y continuous [1,2,3,4,6,9,11,12,13,14,15,16,17,20,21,22,23].

2.2.2. Archimedean Copula

Let φ define a function $\phi:[0,1]\rightarrow[0,\infty]$ which is continuous and provides:

- ✓ $\phi(1)=0,\ \phi(0)=\infty.$
- ✓ For all $t\in(0,1)$, $\phi'(t)<0$,φ is decreasing, for all $t\in(0,1)$ $\varphi''(t)\geq 0$,φ is convex.

φ has an inverse $\varphi^{-1}:[0,\infty]\rightarrow[0,1]$, which has the same properties out of $\phi^{(-1)}(0)=1$ and $\phi^{(-1)}(\infty)=0$. The Archimedean Copula is defined by

$$C(u,v)=\phi^{(-1)}[\phi(u)+\phi(v)]. \tag{4}$$

[10,12,16,19].

2.2.3. Gumbel Copula

This Archimedean copula is defines with the help of generator function $\phi(t)=(-lnt)^{\theta}$, $\theta\geq 1$;

$$C_\theta(u,v)=\exp\left(-[(-\ln u)^{\theta}+(-\ln v)^{\theta}]^{1/\theta}\right) \tag{5}$$

where θ is the copula parameter restricted to$[1,\infty)$. This copula is asymmetric, with more weight in the right tail. Beside this, it is extreme value copula [12].

2.2.4. Clayton Copula

This Archimedean copula is defines with the help of generator function $\phi(t)=\dfrac{t^{-\theta}-1}{\theta}$,

$$C_\theta(u,v)=(u^{-\theta}+v^{-\theta}-1). \tag{6}$$

where θ is the copula parameter restricted to $(0,\infty)$. This copula is also asymmetric, but with more weight in the left tail [13].

2.2.5. Frank Copula

This Archimedean copula is defines with the help of generator function; $\phi(t)=-\ln\dfrac{-e^{-\theta t}-1}{e^{-\theta}-1}$;

$$C_\theta(u,v)=-\frac{1}{\theta}\ln\left(1+\frac{\left(e^{-\theta u}-1\right)\left(e^{-\theta v}-1\right)}{\left(e^{-\theta}-1\right)}\right) \tag{7}$$

where θ is the copula parameter restricted to $(0,\infty)$ [13].

2.2.6. Joe Copula

This Archimedean copula is defines with the help of generator function; $\varphi(t)=-\ln\left[1-(1-t)^{\theta}\right]$

$$C_\theta(u,v)=1-\left[(1-u)^{\theta}+(1-v)^{\theta}-((1-u)^{\theta}(1-v)^{\theta}\right]^{1/\theta} \tag{8}$$

where θ is the copula parameter restricted to $[1,\infty]$. This copula family is similar to the Gumbel. The right tail positive dependence is stronger more than Gumbel [20].

2.2.7. Plackett Copula

This copula function is defines

$$C(u,v)=\frac{1+(\theta-1)-\sqrt{[1+(\theta-1)(u+v)]^2-4\theta(\theta-1)uv}}{2(\theta-1)}. \tag{9}$$

Where θ is the copula parameter restricted to $(0,\infty)$ [20].

2.2.8 Ali Mikhail Haq Copula

This Archimedean copula is defines with the help of generator function $\varphi(t)=\ln\left[1-\theta(1-t)\right]/t$

$$C_\theta(u,v)=\frac{uv}{1-\theta(1-u)(1-v)} \tag{10}$$

where θ is the copula parameter restricted to $\left[-1,1\right]$ [18].

2.3. Measuring Dependence

2.3.1. Spearman Rho

Similar to approach of Pearson correlation coefficient, to compute the correlation between the pairs (R_i,S_i) of ranks have been used. Thus, Spearman's Rho

$$\rho_n=\frac{\sum_{i=1}^{n}(R_i-\bar{R})(S_i-\bar{S})}{\sqrt{\sum_{i=1}^{n}(R_i-\bar{R})^2\sum_{i=1}^{n}(S_i-\bar{S})^2}}\in[-1,1] \tag{11}$$

where

$$\bar{R}=\frac{1}{n}\sum_{i=1}^{n}R_i=\frac{n+1}{2}=\frac{1}{n}\sum_{i=1}^{n}S_i \tag{12}$$

write. This coefficient that stated expediently in the form

$$\rho_n=\frac{12}{n(n+1)(n-1)}\sum_{i=1}^{n}R_iS_i-3\frac{n+1}{n-1}. \tag{13}$$

Also, ρ_n is asymptotically unbiased estimator of

$$\rho=12\int_{[0,1]^2}uvdC(u,v)-3=12\int_{[0,1]^2}C(u,v)dudv-3 \tag{14}$$

where the second equality is obtain. This statement extended;

$$12\int_{[0,1]^2}uvdC_n(u,v)-3=\frac{12}{n}\sum_{i=1}^{n}\frac{R_i}{n+1}\frac{S_i}{n+1}-3=\frac{n-1}{n+1}\rho_n \tag{15}$$

and $C_n\to C$ as $n\to\infty$.Here the null hypothesis $H_0=C=\Pi$ of independence of X and Y, the distribution of ρ_n is normal with zero mean and variance $1/(n-1)$,thus for H_0 approximate $\alpha=0.05$, $\sqrt{n-1}\left|\rho_n\right|>z_{\alpha/2}=1{,}96$ [12,13,14,15].

2.3.2. Kendall Tau

Another measure of dependence is Kendall Tau. This measure based on ranks given by

$$\tau_n = \frac{P_n - Q_n}{\binom{n}{2}} = \frac{4}{n(n-1)} P_n - 1 \tag{16}$$

where P_n and Q_n number of concordant and discordant pairs respectively. Here, $(X_i, Y_i), (X_j, Y_j)$ pairs are concordant $(X_i - X_j)(Y_i - Y_j) > 0$ and these are disconcordant $(X_i - X_j)(Y_i - Y_j) < 0$. If $(X_i - X_j)(Y_i - Y_j) > 0$; we can say $(R_i - R_j)(S_i - S_j) > 0$. τ_n is function of copula C_n. As $n \to \infty$, $C_n \to C$, $W = \frac{1}{n}\sum_{j=1}^{n} I_{ij} = \frac{1}{n}\#\{j : X_j \le X_i, Y_j \le Y_i\}$,

$$\tau_n = 4\frac{n}{n-1}\bar{W} - \frac{n+3}{n-1} = 4\int_{[0,1]^2} C(u,v)dC(u,v) - 1 \tag{17}$$

written. τ_n is asymptotically unbiased estimator of τ and τ_n is normal with zero mean and variance $2(2n+5)/\{9n(n-1)\}$. Here the null hypothesis $H_0 = C = \Pi$ of independence of X and Y, thus for H_0 approximate $\alpha = 0.05$, $\sqrt{9n(n-1)/2(2n+5)}\,|\tau_n| > 1.96$ [12, 13, 14, 15, 22].

Table 1: Generator, Parameter space, Kendall Tau and Spearman Rho values of Special Copula Families

Family	Generator	Parameter	Kendall Tau	Spearman Rho
Gumbel	$\phi(t) = (-lnt)^{\theta}$	$\theta \in [1, \infty)$	$\frac{\theta - 1}{\theta}$	
Clayton	$\phi(t) = \frac{t^{-\theta} - 1}{\theta}$	$\theta \in [0, \infty)$	$\frac{\theta}{\theta + 2}$	
Frank	$\phi(t) = -\ln\frac{-e^{-\theta t} - 1}{e^{-\theta} - 1}$	$\theta \in (-\infty, \infty)$	$1 - \frac{4}{\theta}[1 - D_1(\theta)]$	$1 - \frac{12}{\theta}[D_2(-\theta) - D_1(-\theta)]$
Joe	$\varphi(t) = -\ln[1 - (1-t)^{\theta}]$	$\theta \in [1, \infty)$	$1 + \frac{4}{\theta} D_J(\theta)$	-
Placket	-	$\theta \in (0, \infty)$	-	$\frac{\theta + 1}{\theta - 1} - \frac{2\theta \ln \theta}{(\theta - 1)^2}$

2.4. Copula estimation

2.4.1. Maximum Likelihood Method (MLE)

Maximum likelihood method is the most used for copula. The aim of the method is basic to find the parameters that make the likelihood functions get its maximum value. It is given

$$f(x_1, x_2, ..., x_n) = c(F_1(x_1), F_2(x_2), ..., F_n(x_n))\prod_{j=1}^{n} f_j(x_j) \tag{18}$$

$$c(F_1(x_1), F_2(x_2), ..., F_n(x_n)) = \frac{\partial^n c(F_1(x_1), F_2(x_2), ..., F_n(x_n))}{\partial F_1(x_1), F_2(x_2), ..., F_n(x_n)}.$$

Let $\{x_{1t}, x_{2t}, ..., x_{nt}\}_{t=1}^{T}$ is the sample data matrix, the likelihood functions can be given

$$l(\theta) = \sum_{t=1}^{T} \ln(c(F_1(x_{1t}), F_2(x_{2t}), ..., F_n(x_{nt})) + \sum_{t=1}^{T}\sum_{j=1}^{n} \ln f_j(x_{jt}). \tag{19}$$

Accordingly, the maximum likelihood estimator is

$$\hat{\theta}_{MLE} = \max_{\theta} l(\theta) . \quad [12, 13, 14, 15]$$

2.4.2. Inference for marginal (IFM)
This method is used to overcome the drawbacks of full maximum likelihood function. The aim of copula theory is separate between the univariate margins and the dependence structure. From equation (19)

$$l(\theta) = \sum_{t=1}^{T} \ln(c(F_1(x_{1t},\theta_1), F_2(x_{2t},\theta_2),...,F_n(x_{nt},\theta_n),\alpha) + \sum_{t=1}^{T} \sum_{j=1}^{n} \ln f_j(x_{jt},\theta_j) \quad (20)$$

write. In this equation (19) the vector of the parameters for the univariate marginal $\theta = (\theta_1, \theta_2, ..., \theta_n)$ and α is vector the parameters of copula. Accordingly, the fundamental idea of inference for margins is that it is forecasts the parameters for marginal distributions and copula separately in two stages.

- ✓ Estimate the parameters θ_j from marginal distributions,

$$\hat{\theta}_j = \arg\max_{\theta_t} \sum_{t=1}^{T} \ln f_j(x_{jt};\theta_j) \quad (21)$$

- ✓ Estimation of the vector of the copula parameters α, used the $\hat{\theta} = (\hat{\theta}_1, \hat{\theta}_2, ..., \hat{\theta}_n)$;

$$\hat{\alpha}_{IFM} = \arg\max_{\alpha} \sum_{t=1}^{T} \ln(c(F_1(x_{1t},\hat{\theta}_1), F_2(x_{2t},\hat{\theta}_2),...,F_n(x_{nt},\hat{\theta}_n);\alpha) \quad (22)$$

[12, 13, 14, 15].

2.5. Tail Dependence of Copulas
In order to estimate the copula from bivariate observational data sets, we use the tail dependence concept. It relates the amount of dependence in the upper-right quadrant tail or in the lower-left-quadrant tail of a bivariate distribution. The upper and lower tail dependence parameters; If a bivariate copula C is such that; it is that upper tail dependence written,

$$\lambda_U = \lim_{v \to 1} \frac{1-2v+C(v,v)}{(1-v)} \quad (23)$$

Similarly, lower tail dependence is written;

$$\lambda_L = \lim_{v \to 0} \frac{C(v,v)}{v} . \quad (24)$$

Table 2: For copula familes upper and lower tail dependence

Copula Family	λ_U	λ_L
Gumbel	$2-2^{1/\theta}$	0
Joe Copula	$2-2^{1/\theta}$	0
AMH Copula	0	$= \begin{cases} \lim_{v\to 0} v/1-\theta(1-v)^2 = 0,5 & for\ \theta = 1 \\ \lim_{v\to 0} v/1-\theta(1-v)^2 = 0,5 & for\ \theta < 0 \end{cases}$
Clayton Copula	0	$2^{-1/\theta}$
Frank Copula	0	0
Plackett Copula	0	0

[4,18].

2.6. Copula-GARCH Estimation

There are some approaches to model dependence. Many researchers prefer multivariate normal and t distribution to model in applications and GARCH model is widely used in this application. So, we prefer copula instead of multivariate GARCH to model dependence. The most important feature of copula is not requiring any assumptions of the margins normal distribution. Beside this, copula permit to separate a high dimensional joint distribution into its marginal distributions and copula function use to link them together. For GARCH model, there are many parameters which estimation more difficult. Compare to multivariate GARCH models and other multivariate models, copula is more suitable to model dependence structure. For the series, to model dependence structure, other selection criteria are Akaike's information criterion (AIC) and Schwarz's criterion (SIC).These;

$$AIC = -2\log L + 2k / n \qquad (25)$$

$$SIC = -2\log L + k\ln(n) / n. \qquad (26)$$

Here, k is the number of estimated parameter for each model, n size of sample [3,19].

3. Application

3.1. Data Description

In this study, I used data set (X, Y, Z, T) which generated from Weilbull distribution. I define the log-returns of series. Table 3 and Table 4 contain respectively descriptive statistics of X, Y, Z, T series and X, Y, Z, T return series. As submitted in these results, the means of X, Y, Z, T series are not nearby to zero and standard deviations are a little bit. The Skewness means that X, Y, Z, T series are positive. The Kurtosis of X, Y, Z, T series are positive. The meaning of positive skewness is that X, Y, Z, T series have the longer right tail of density.

Table 3: Descriptive statistics of X,Y,Z,T series

	X	Y	Z	T
mean	1,041126	0,939809	0,991116	1,059747
median	0,747425	0,615185	0,670895	0,777685
maximum	6,726771	7,982274	8,028318	5,703414
minumum	0,000522	0,000671	0,005108	0,006594
Std.dev.	1,064711	0,963039	1,026534	0,967569
Skewness	2,205341	2,153105	2,438068	1,563574
Kurtosis	9,755806	11,01666	12,41151	5,763879
Jarque-Bera	1084,917	1380,170	1872,554	290,3015

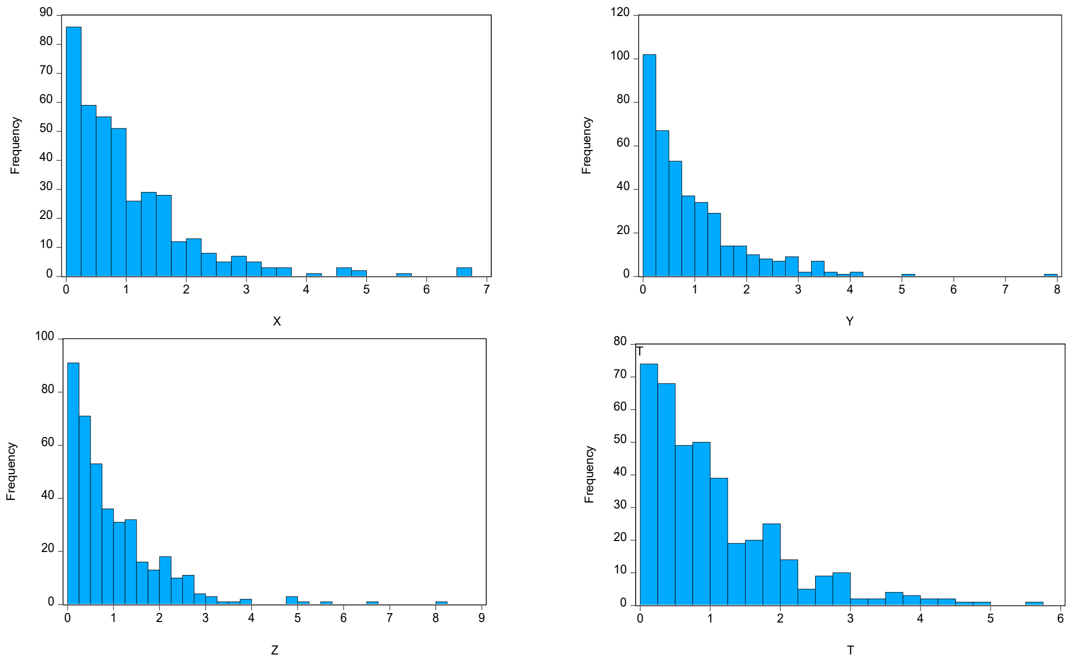

Figure 1: Frequency of X, Y, Z and T series

Table 4: Descriptive statistics of X,Y,Z,T return series

	X	Y	Z	T
mean	-0,007332	-0,000379	0,002451	0,001740
median	0,008150	-0,035048	-0,008549	-0,096574
maximum	5,858241	7,341030	5,238800	5,813359
minumum	-6,040652	-6,934251	-5,860342	-5,833584
Std.dev.	1,765448	1,880493	1,707246	1,592205
Skewness	0,004231	0,155597	0,139830	0,187150
Kurtosis	3,739595	3,666246	3,727014	3,606463
Jarque-Bera	9,095071	8,989556	10,08736	8,443801

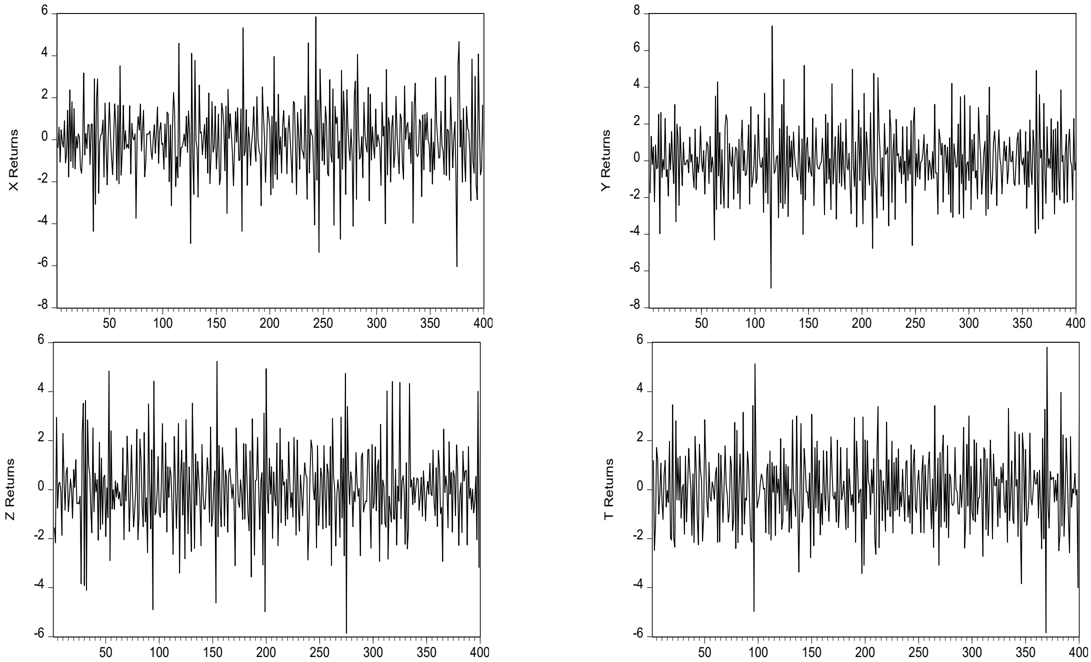

Figure 2: Returns of X, Y, Z and T series

3.2. Modeling the marginal distribution

In table 3,4,5,6, for X, Y, Z and T return series are given marginal modeling. In these tables, there are coefficients for variance equation. In the equation (1) w is C, α is ARCH (1) and β is GARCH (1). Accordingly this equation, the sum of the ARCH and GARCH coefficients ($\alpha + \beta < 1$) is very close to one, indicating that volatility shocks for this series are quite persistent. This result is often observed in high frequency data.

Table 5: X return Series Marginal Modeling

	Gaussian	Standard Error
C	2,403845	0,382825
ARCH (1)	0,397481	0,099624
GARCH(1)	-0,137874	0,099005
LogL	-775,4711	-
AIC	3,907123	-
SIC	3,947113	-

Table 6: Y return Series Marginal Modeling

	Gaussian	Standard Error
C	2,414059	0,519193
ARCH (1)	-0,335428	0,104123
GARCH(1)	-0,017985	0,120611
LogL	-801,0585	-
AIC	4,035381	-
SIC	4,075370	-

Table 7: Z return Series Marginal Modeling

	Gaussian	Standard Error
C	2,200512	0,349086
ARCH(1)	0,393349	0,104596
GARCH(1)	-0,155193	0,110172
LogL	-754,4844	-
AIC	3,801927	-
SIC	3,841916	-

Table 8: T return Series Marginal Modeling

	Gaussian	Standard Error
C	1,330661	0,372758
ARCH(1)	0,339488	0,100450
GARCH(1)	0,125565	0,180168
LogL	-724,8858	-
AIC	3,678625	-
SIC	3,718615	-

3.3. With Copula Modeling of the Dependence Structure

In this study, to model dependence, I present five copula families. I used to select Kendall's Tau and Spearman's Rho rank correlation statistics in our study, so the correlations parameters corresponding to each copula are obtained based on Kendall's Tau and Spearman's Rho. Maximum Likelihood Estimation method is used applied to estimation copula parameters. Accordingly, in table 11, 12, 13, 14, 15, 16 for copula families parameter values and Logl**,** AIC and SIC values is calculated. According to this values, with the help of equation, (19), (25) and (26), in table 11, relationship of X and Y series is positive weak relation and based on the AIC and SIC value we conclude that dependence structure of X and Y series is modeled by Ali Mikhail Haq copula ($\theta = 0,14722356$), in table 12 relationship of Z and T series is positive weak relation and based on the AIC and SIC value we conclude that dependence structure of Z and T series is modeled by Clayton copula ($\theta = 0,0682523$), in table 13, relationship of X and Z series is negative weak relation based on the AIC and SIC value we conclude that dependence structure of X and Z series is modeled by Frank ($\theta = -0,108012$), similarly in table 14, in table 15 and in table 16 respectively, relationship of X and T series is negative weak relation and based on the AIC and SIC value we conclude that dependence structure of X and T series is modeled by Frank ($\theta = -0,351430$), relationship of Y and Z series is positive weak relation and based on the AIC and SIC value we conclude that dependence structure of Y and Z series is modeled by Ali Mikhail Haq ($\theta = 0,053274$), relationship of Y and T series is negative weak relation and based on the AIC and SIC value we conclude that dependence structure of Y and T series is modeled by Frank ($\theta = -0,072003$).

Table 9: For X, Y, Z, T series Kendall Tau (τ) rank correlation

	X	Y	Z	T
X	1	0,034	-0,012	-0,039
Y	0,034	1	0,012	-0,008
Z	-0,012	0,012	1	0,033
T	-0,039	-0,008	0,033	1

Table 10: For X, Y, Z, T series Spearman Rho (ρ) rank correlation

	X	Y	Z	T
X	1	0,05	-0,019	-0,059
Y	0,05	1	0,015	-0,013
Z	-0,019	0,015	1	0,049
T	-0,059	-0,013	0,049	1

Table 11: X and Y series Dependence Structure Modeling

Copula Family	θ	σ	Logl	AIC	SIC
Joe Copula	1,061005	0,002373	-95,8729	191,7558	191,7588
AMH Copula	0,1472356	0,0025	0,208139	-0,4066278	-0,386320
Clayton Copula	0,070393	0,002246	-0,24994	0,50988	0,51289
Frank Copula	0,306286	0,002714	-59,874	119,758	119,761
Plackett Copula	1,161695	0,002504	-632,822	1265,654	1265,657

Table 12: Z and T series Dependence Structure Modeling

Copula Family	θ	σ	Logl	AIC	SIC
Joe Copula	1,059141	0,002368	-102,134	204,278	204,281
AMH Copula	0,1430673	0,002501	0,226331	-0,44266	-0,43965
Clayton Copula	0,0682523	0,002252	0,625233	-1,24047	-1,23746
Frank Copula	0,2972623	0,002545	-57,9673	115,9446	115,9476
Plackett Copula	1,158477	0,004427	-639,803	1279,616	1279,619

Table 13: X and Z series Dependence Structure Modeling

Copula Family	θ	σ	Logl	AIC	SIC
Joe Copula	0,979581	0,002351	-49,1176	98,2452	98,24821
AMH Copula	-0,054732	0,002532	0,030216	-0,05043	-0,04742
Clayton Copula	-0,023715	0,002224	0,112861	-0,21572	-0,21271
Frank Copula	-0,108012	0,000331	17,68412	-35,3582	-35,3552
Plackett Copula	0,9445883	0,0025	-1005,09	2010,19	2010,193

Table 14: X and T series Dependence Structure Modeling

Copula Family	θ	σ	Logl	AIC	SIC
Joe Copula	0,9356073	0,002369	-25,5028	51,0156	51,01861
AMH Copula	-0,183338	0,002632	0,292312	-0,57462	-0,57161
Clayton Copula	-0,075072	0,002382	0,509709	-1,00942	-1,00641
Frank Copula	-0,351430	0,003511	48,15021	-96,2904	-96,2874
Plackett Copula	0,837624	0,002504	-631,274	1262,558	1262,561

Table 15: Y and Z series Dependence Structure Modeling

Copula Family	θ	σ	Logl	AIC	SIC
Joe Copula	1,020986	0,002353	-73,1704	146,3508	146,3538
AMH Copula	0,053274	0,002503	0,015528	-0,02106	-0,01805
Clayton Copula	0,024291	0,002295	-0,11522	0,24044	0,24345
Frank Copula	0,018012	0,000391	-19,7092	39,4284	0,24345
Plackett Copula	1,046031	0,00251	-1069,54	2139,09	2139,093

Table 16: Y and T series Dependence Structure Modeling

Copula Family	θ	σ	Logl	AIC	SIC
Joe Copula	0,098325	0,002347	-53,7173	107,4446	107,4476
AMH Copula	-0,036351	0,002523	0,015474	-0,02095	-0,01794
Clayton Copula	0,015873	0,001967	-0,01493	0,03986	0,04287
Frank Copula	-0,072003	0,000148	12,03848	-24,067	-24,0639
Plackett Copula	0,961748	0,002501	-1133,87	2267,75	2267,753

4. Conclusion

In this paper, I based on investigate the structure of dependence between X, Y, Z and T which are generated Weilbull distribution. Thus I used Copula- GARCH approach. Primarily, I formed the marginal distribution using GARCH (1,1) method with Gaussian distribution. From this observed results, X, Y, Z, and T series were to close each other and had high frequency data. Also, these series have a strong long-term persistence in the volatility. For dependency structure between X, Y, Z, and T series, copula functions are used. The Copula is made up of six pairs that (X,Y), (Z,T), (X,Z),(X,T),(Y,Z) and (Y,T).The dependence of (X,Y) is modeled Ali Mikhail Haq copula with the parameter value of 0,1472356, Kendall Tau 0,034 and Spearman Rho 0,05, the dependence of (Z,T) is suitable copula Clayton copula with the parameter value of 0,0682523, Kendall Tau 0,033 and Spearman Rho 0,049, the dependence of (X,Z) is best copula Frank copula with the parameter value of -0,108012, Kendall Tau -0,012 and Spearman Rho -0,019. Likewise, for the dependence of (X,T), (Y,Z) and (Y,T) are best copulas respectively, Frank copula with the parameter value of -0,351430, Kendall Tau -0,039 and Spearman Rho -0,059, Ali Mikhail Haq Copula with the parameter value of 0,053274, Kendall Tau 0,012 and Spearman Rho -0,015, Frank Copula with the parameter value of -0,072003, Kendall Tau -0,008 and Spearman Rho -0,013.

Conflict of interest: The authors declare they have no potential conflicts of interest with respect to the research, authorship, and/or publication of this article, and declare study has ethical permissions if required.

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Ethical issues: All Authors declare that Originality of research/article etc... and ethical approval of research, and responsibilities of research against local ethics commission are under the Authors responsibilities. The study was conducted due to defined rules by the Local Ethics Commission guidelines and audits.

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A study on the distribution and population status of the Whooper Swan (*Cygnus cygnus l.* 1758) in the Van lake basin

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Abstract

Objective: In this study, it was aimed to determine status, population size, stop over sites, threats and daily relocation activity of the Whooper swan in the Van Lake Basin.

Material and Methods: This study based on the observation data of the Whooper swan that spends the winter in the Van Lake Basin, during 2015 season. The observations were conducted by Point Counts method in the six areas which the species are intensively seen. The data was analysed with the help of IDW (Inverse Distance Weighting) interpolation and point density methods in the Arcmap 10.2 program.

Results: It was determined that The Whooper swan came into the Van Lake Basin mostly at the last week of November and left at the last week of March. It is revealed as a winter visitor species that spends about 4 months in the area. However it was seen in many points of the area, it is seen that it lodges in mostly 6 points. During the study, at the beginning of the winter totally 240 individuals were detected as follows; 71 individuals at Arin Lake – the maximum, 63 in Yaylıyaka reeds, 52 in Göründü reeds, 23 in Çelebibağ reeds, 17 in Dönemeç Delta, and 14 in Bendimahi Delta. At the end of the winter, the maximum number of individuals in the whole basin was recorded as 172.

Conclusion: At the beginning of the winter 2015, totally 240 individuals were counted in the basin. But it was seen that the number decreased to 172 towards the spring migration. Then there showed up a conclusion that totally 68 individuals (28.34%) in the basin had been perished because of various causes and could not have a chance to return to their breeding sites. It was realized that there happened a population reduction in the basin when compared with the by past studies related to the species. It was presented that hunters, foxes and dogs were the most important role perishing the species. It was detected that the species spends the night along the shore line considered as safe and feed at shallow spaces along the shore. The performed study confirmed once more the Whooper swan overwinters in the Van Lake Basin. Furthermore the study revealed the species should be protected by scientific data.

Key Words: Whooper swan, *Cygnus cygnus*, Arcmap 10.2, Van Lake Basin, Arin Lake, Yaylıyaka reeds

Introduction

Wetlands are regarded as important sites for many living in terms of resting, feeding, breeding, sheltering and daily relocation activities (1). Turkey is generally known to be having a great potential for wetlands according to its geographical location (2, 3). A great part of these wetlands are located in the Eastern Anatolia Region. One of the important areas located in the Eastern Anatolia Region is the Van Lake Basin. The basin has important habitats especially for waterbirds in its vicinity due to its location. These wetlands have become important haunts for feeding, resting, breeding and lodging activities for bird species (4-7).

Remote sensing methods are used in numerous fields including wetlands in the world and our country. Detecting the wetland protective plans and species-spaces relationship by the GIS (Geographic Information System) being one of the remote sensing methods is a very common application. For recent terms, that method has been preferred to determine habitat preferences and population volumes of birds using the wetlands (8-14).

Most of the references show Whooper swan as winter visitor in Turkey and Europe. References do not indicate the presence of species in the Van Lake Basin.

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There is only one reference of information about the presence of the species in the basin (15-17).

During the recent years, it commonly came to discussion the direct and indirect influence of the anthropogenic based activities on the bird populations (18-20).

The first detection of Whooper swan in The Van Lake Basin was occurred in end of Otober 1995 (5). First data was received from Arin Lake, and about 164 individuals. After that study, the data about existence of that species in the basin and Eastern Anatolian Region continued as enlarging (21).

The distribution in Van Lake Basin, population volume, habitat preferences and its reactions against environmental effects of the species still have not been searched enough. Moreover there is not any study about daily feeding, overnighting and changing location behaviors of the species either. This study was planned to find the answers to the questions listed above as also utilizing GIS techniques.

Material and Methods

This study was conducted in Arin Lake, Yaylıyaka reeds, Göründü reeds, Çelebibağ reeds, Dönemeç Delta and Bendimahi reeds and, in Van Lake Basin.

Arin Lake is a shallow lake located in the north of Van Lake. A fine sand barrier separates these two lakes. It is fed with surface rains and little springs. Soda rate is higher than Van Lake. Its flowing is into the Van Lake. There are three village settlements along Arin Lake (Figure 2).

Yaylıyaka reeds is an arc-shaped bay on the eastern side of Van Lake. There is one village on the each end of the bay. After narrow reed band, there are fields (Figure 3).

Göründü reeds is located in the South of Van Lake. Van – Tatvan highway passes by the reeds. There is a village on the northern boundary of the area. There is a cultivated area around the reeds. A narrow dune runs from the reeds into lake (Figure 4).

Çelebibağ reeds (Erciş), is on the northern coast of Van Lake. It is located in the area where Zilan Creek meets with the lake. The mud planes which start just after settlement reach out until the lake. In that area, there are partly reeds. There is a historical cemetery at shore and a castle which became an island due to the rising level of the water (Figure 5).

Dönemeç Delta is located on the southeastern part of Van Lake. It was formed at place where Engil Creek flows into the lake. There is a village on the both sides of the lake. The cove being alike a bay houses a lot of reeds. After reeds, a sand dune band separates the delta from lake (Figure 6).

Bendimahi Delta is on the northeastern side of Van Lake. It was formed in the place where the creek called as the same name flows into lake. There are meanders, intense reeds and reeds islands along the creek bed. There are villages along the creek bed. There is narrow sand dune at where the delta meets with the lake (Figure 7).

Migration time, distribution, population volume, habitat preferences and daily relocation activities of the species being a winter visitor in the basin were examined. The study was performed during the period between November 2014 and April in 2015. Data are based on the field observations of three days for each month. Field works were conducted between 06:00 am and 19:00 pm.

Point Counts Method (22) was used for determining the density of the species population and their daily relocation activities. All numerical data was analyzed by the IDW (Inverse Distance Weighting) interpolation and point density methods via Arcmap 10.2 program.

In studies; a 1/25000 scaled digital map of the area, terrain observation cards, binoculars, telescope, numbering machine, camera, distance meter, zodiac boat and GPS (Global Positioning System) were used.

After specifying the contours of detected six areas, each layer was converted into a 0.25 km² ArcMap 10.2 square format. The population distribution was done as taking 3 UTM coordinates in each designated 0.25 km² area into account. Then DEM maps were produced. These maps were used as the subdivisions of necessary studies to be conducted by GIS after transferring them into digital media (Fig.1).

Findings

The Whooper swan mostly comes into Van Lake Basin at the last week of November and leaves at the last week of March. It is a winter visitor species that stays in the area for about four months. Even thought is seen in a lot of places in the basin, it stops over intensely in six points. During the study, at the beginning of the winter totally 240 individuals were detected as follows; 71 individuals at Arin Lake – the maximum, 63 ones in Yaylıyaka reeds, 52 ones in Göründü reeds, 23 ones in Çelebibağ reeds, 17 ones in Dönemeç Delta, and 14 ones Bendimahi Delta. At the end of the winter, the maximum number of individuals in the whole basin was recorded as 172 (Table 1).

Table 1: The observation results of the Whooper swan in Van Lake Basin during the winter of 2015.

Area Name	At the beginning of Winter Maximum Individual Number	At the end of the Winter Maximum Individual Number	Difference
Arin Lake	71	49	22 (% 9,17)
Yaylıyaka reeds	63	45	18 (% 7,5)
Göründü reeds	52	38	14 (% 5,83)
Çelebibağ reeds	23	17	6 (% 2,5)
Dönemeç Delta	17	13	4 (% 1,67)
Bendimahi Delta	14	10	4 (% 1,67)
Total	**240**	**172**	**68 (% 28,34)**

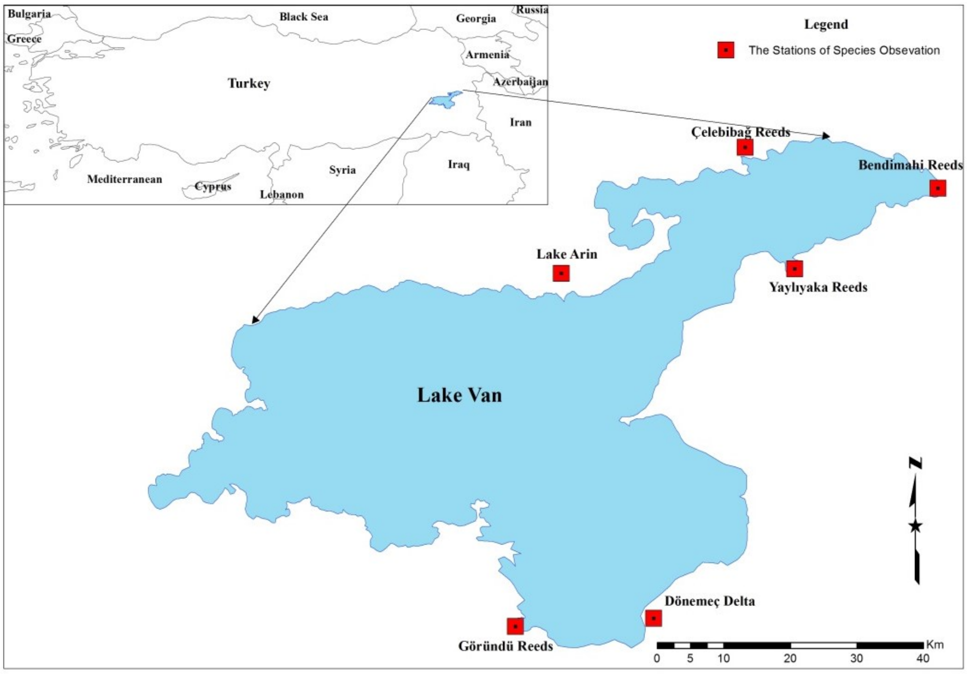

Figure 1: Location map of areas where the Whooper Swan was seen

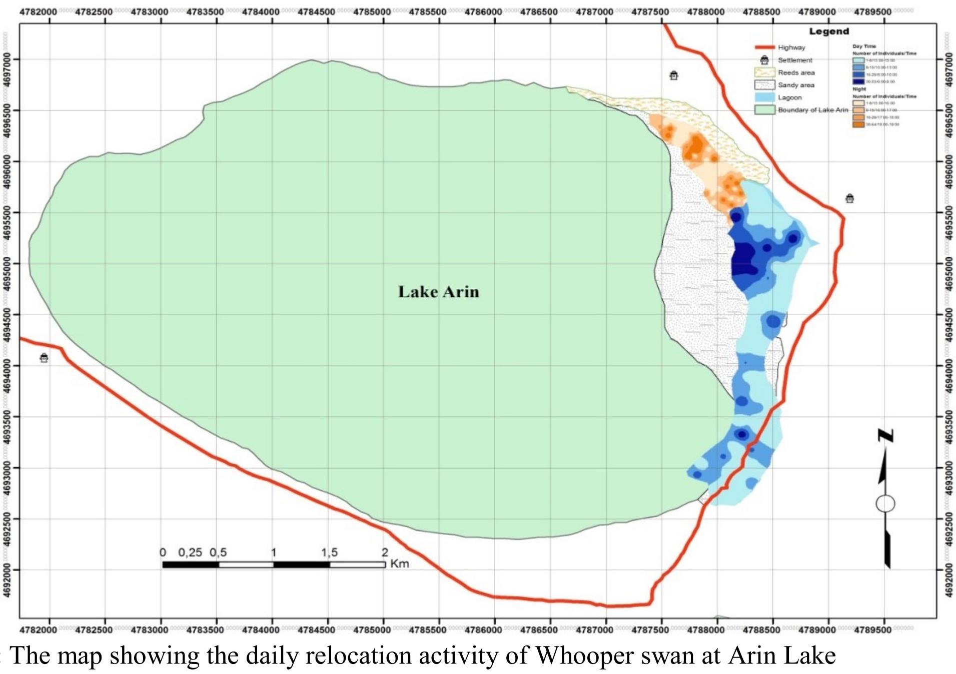

Figure 2: The map showing the daily relocation activity of Whooper swan at Arin Lake

Arin Lake is a very impotant wintering area for Whooper swan. As the sun goes up, the species moves away from the dune to the openings of the lake. Even if they were scattered in various directions in the event of danger, it was observed that they came back again later. Species spend the night on the shore. During the observations at this lake, maximum 71 individuals were counted in November. In the same area, there recorded maximum 49 individuals in March (Figure 2).

Maximum 63 individuals of whooper swans were counted in Yaylıyaka reeds. The reeds are the most important hunting grounds. Dogs and foxes also frequently stop by that field. The whooper swan that feeds at the openings during the day spends the night at the narrow sand band. It was observed that they mostly fly to the island being in the opposite of the bay when they are annoyed. Maximum 45 individuals were counted in the middle of March (Figure 3).

During the winter the connection of dune with land is cut due to rising of the water level and it becomes a little island in Göründü reeds. The Whooper swan spends the night in that area. During the day they feed in the lake plate among reeds and openings. In that area, the most severe damage to the species is the hunters. When they are annoyed, they fly towards the close islands. Maximum 52 individuals were counted in the field during December and towards the end of February maximum 38 individuals were observed (Figure 4).

Çelebibağ reeds is other important wintering area for Whooper swan. Species spends the night at shore line of muddy land or shore of the island. During the day, they feed at shallow shore lands. When they are annoyed, they move towards openings of the lake. It was observed that the species is annoyed by mostly hunters, foxes and dogs. At the beginning of winter, maximum 23 individuals were counted and it was found that number had decreased to 17 towards the spring (Figure 5).

Image 1: Whooper Swans, Van lake, Turkey

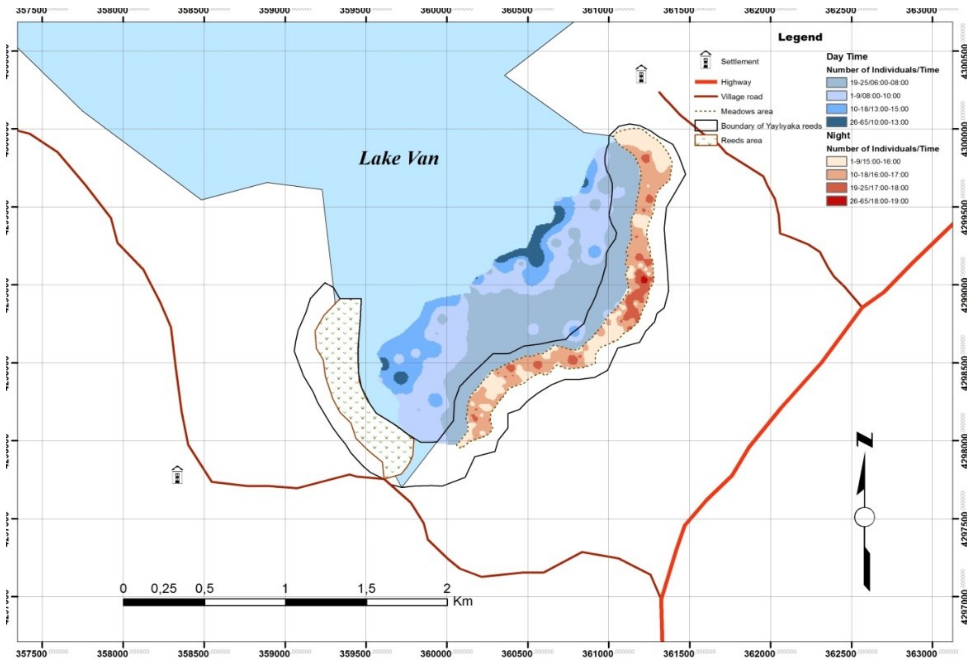

Figure 3. The map showing the daily relocation activity of the Whooper swan in Yaylıyaka reeds

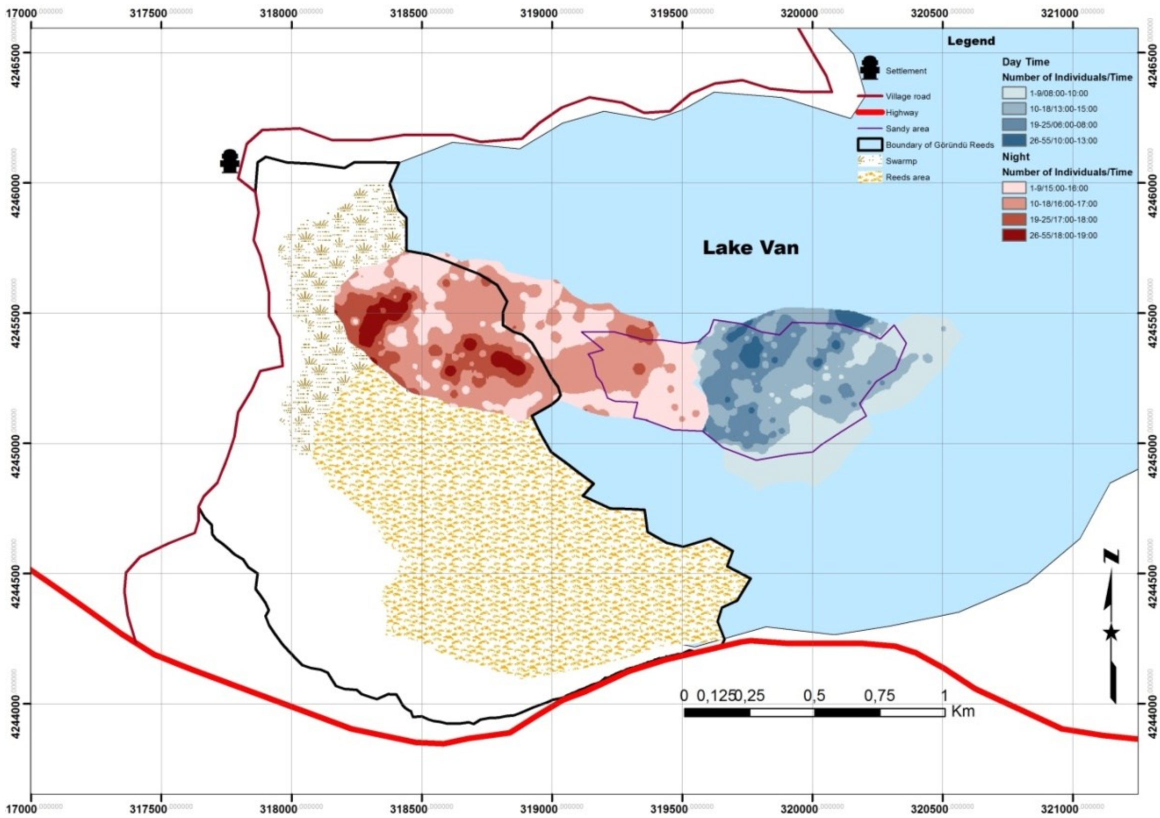

Figure 4: The map showing the daily relocation activity of the Whooper swan in Göründü reeds

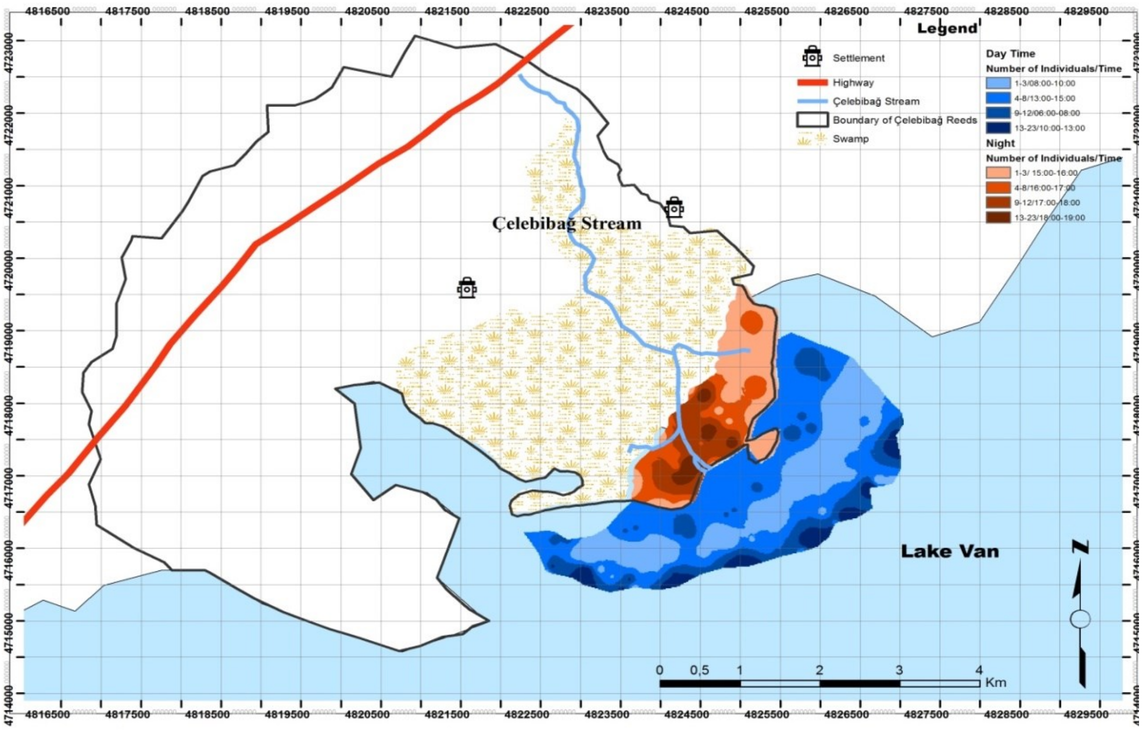

Figure 5: The map showing the daily relocation activity of the Whooper swan in Çelebibağ reeds

At the beginning of winter, maximum 17 individuals were observed in Dönemeç Delta. As closing the spring migration, that number was found as maximum 13 (Figure 6). It was seen that the species feeds at shallow reeds plate and shallow shores of lake. At nights, they overnight on the sand dune. Foxes, wandering dogs and anthropogenic effects have a negative influence on the species also in that area.

During the daylight, the Whooper swan feeds at shallow parts of lake and at night they usually overnight on the dune band in Bendimahi Delta. In that area, maximum 14 individuals were observed at the beginning of the winter. But at March, maximum number of observed individuals was 10 (Figure 7). Also in that area, hunters, fixes and dogs give harm to the species.

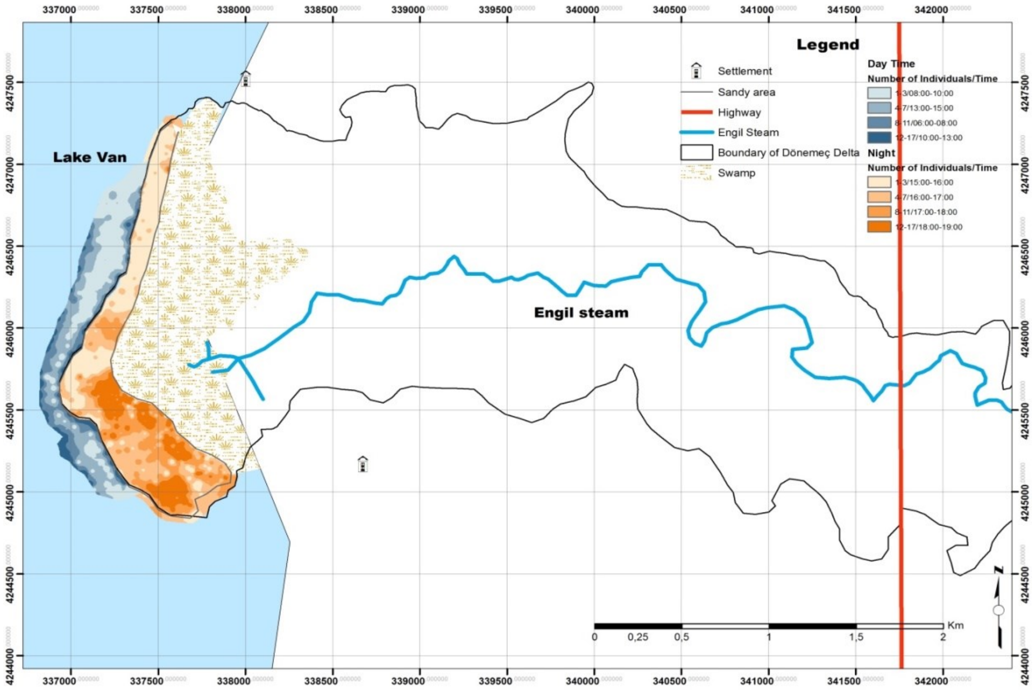

Figure 6. The map showing the daily relocation activity of the Whooper swan in Dönemeç Delta

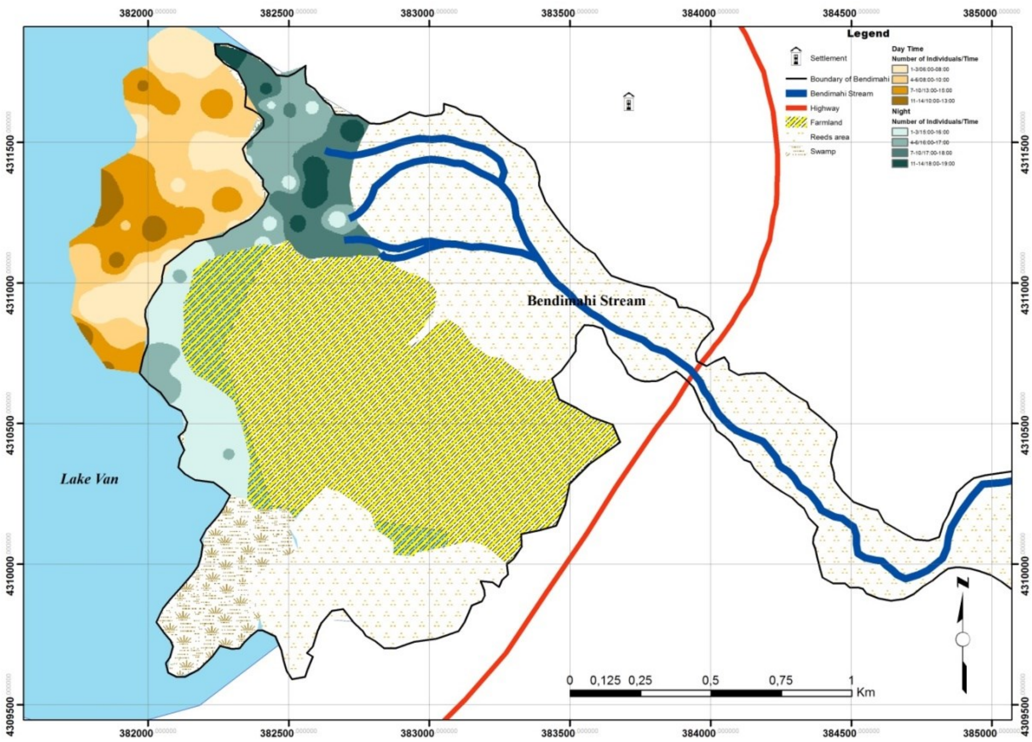

Figure 7. The map showing the daily relocation activity of the Whooper swan in Bendimahi Delta

Discussion

It was determined that the Whooper swans were concentrated intensively in the Van Lake Basin at six locations during winter. At the beginning of winter, maximum 240 individuals were counted in the whole basin. But it was seen that the number decreased to 172 towards the spring migration. In that case, there showed up a conclusion that totally 68 individuals (28.34%) in the basin had been perished because of various causes and could not have a chance to return to their breeding sites. An individual killed by the hunters during the work was seen. In addition, at least three dead individual feather remnants were seen.

It was realized that there happened a population reduction in the basin when compared with the by past studies related to the species. Adızel reported 164 individuals at the Arin Lake in end of October 1995. But in this study, maximum 71 individuals were counted in that area. Adızel et al counted maximum 102 individuals in Yaylıyaka reeds between 2007 and 2009. In that same area, maximum 63 individuals were counted. However the status of the species is classified as Least Concern (LC) according to IUCN criteria, these results apparently showed that the species should be protected.

The species is known as white goose. Even if a lot of factors may affect the species, its most important enemy is hunters. Especially during the darkness of night, foxes and dogs also hunt the Whooper swans.

It came to conclusion that the groups settling down in the stated areas at the beginning of the winter stay in these areas until the spring migration. Even if they scatter into various directions when in danger, they come back to same areas later.

In all observed areas, it was seen that the species feed at shallow shore line during whole day. When they are annoyed, they move towards openings. During the rests they moved on the dunes at shore line. It was concluded that the species do not prefer much to go into reeds due to safety issues. They are rarely seen in the wide water plates among the reeds. The species generally overnight on the sand dune band separating the lake and lagoon. The shore line or islands are also the places they spend the night. They wait without any move under the snow falling over them. Thus they became snow balls.

Conclusion

It has been observed that the species rarely moves while getting rest in near costal open areas of the lake within hours in which human activities are intense. However, it has been identified that they move to feed especially in dune and swamp areas by getting close to coast.

Çelebibağ reeds and Bendimahi Delta have the most anthropogenic factors compared to the others four areas. Therefore, activities of changing location differ greatly in these areas.

Protection of this species and others in the area depends directly on the living being themselves and on removing the dangers towards their habitats.

The performed study confirmed once more that the Whooper Swan spends the winter in Van Lake Basin. That information is an important contribution to determine the range of the species. As a result of the study, the areas the species mostly exists, the habitat requirements, the state of population and the treats are tried to be revealed. We hope that this scientific information will contribute to the protection of the species.

Conflict of Interest: The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Author's Contributions: EA, OA: Collecting of data, writing and revision of article, **EA:** Field work

Ethical issues: All Authors declare that Originality of research/article etc... and ethical approval of research, and responsibilities of research against local ethics commission are under the Authors responsibilities. The study was conducted due to defined rules by the Local Ethics Commission guidelines and audits.

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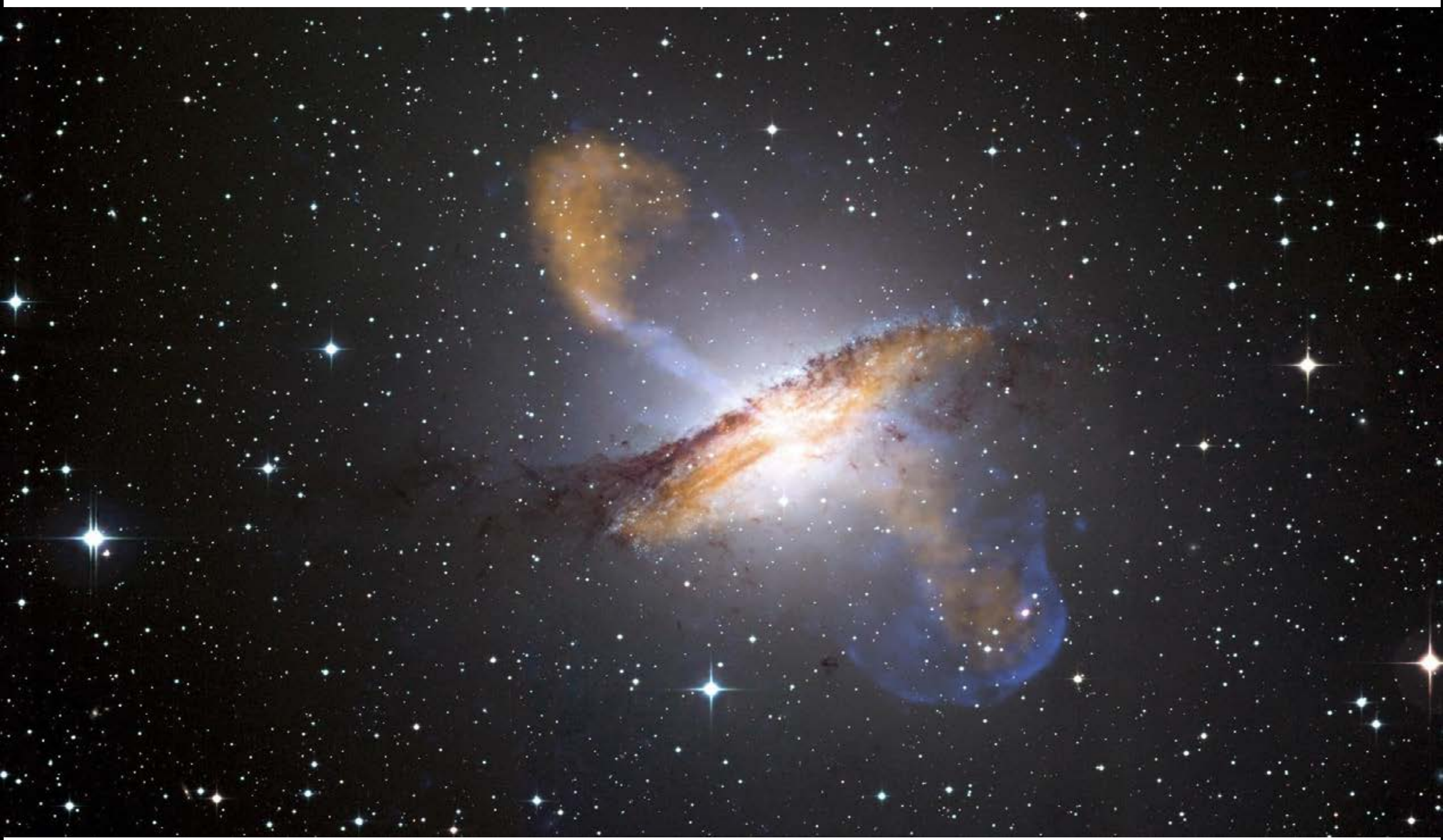

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