ANOVA and the 2-Tuple Neutrosophic linguistic method: A case study to analyze the interaction between elements

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Abstract

In this article, an innovative approach is presented that combines analysis of variance (ANOVA) with the Neutrosophic 2-Tuple linguistic method to explore and analyze the complex interactions between elements in various contexts. ANOVA, known for its ability to decompose variance and detect significant differences between groups, is here merged with the Neutrosophic method, which provides tools to handle the uncertainty and linguistic ambiguity present in many real data sets. This methodological synergy not only expands analytical possibilities, but also allows for a more nuanced and profound interpretation of the relationships between variables, overcoming the limitations of traditional approaches that assume absolute certainty in the data. Through detailed case studies and practical examples, it is demonstrated how this hybrid model can be effectively applied in fields as diverse as scientific research, business management, and public policy evaluation. The results obtained illustrate how the combination of ANOVA and 2-Tuple Neutrosophic not only improves the precision of statistical analysis, but also enriches the understanding of complex phenomena by considering and modeling uncertainty in a more realistic and adaptable way to different contexts and scenarios.

Keywords: 2-Linguistic neutrosophic tuples; ANOVA; (t, i, f)Neutrosophic structure

1. Introduction

Analysis of variance (ANOVA) has been a cornerstone in statistical research to discern significant differences between groups and understand the influence of independent variables on a dependent variable. Its application extends from experimental studies to observational data analysis, standing out for its ability to decompose variance and provide crucial elements in fields as diverse as medicine, psychology and engineering [1]. However, ANOVA faces challenges when dealing with data that is ambiguous or subject to multiple interpretations, where linguistic uncertainty can distort traditional results. In contrast, the 2-Tuple Neutrosophic linguistic method introduces a novel approach to addressing this inherent ambiguity through a philosophical and mathematical lens. Developed by Florentin Smarandache, this method allows us to handle imprecision and inconsistency in the interpretation of data, recognizing that many times measurements and observations cannot be defined with absolute certainty. This ability to capture linguistic uncertainty is crucial in contexts where variables can have varying degrees of truth, falsity, and indeterminacy, common situations in qualitative studies and opinion analysis [2].

The present study focuses on the innovative fusion of ANOVA and the Neutrosophic 2-Tuple method as a model to analyze the interaction between elements in various scenarios. This combination seeks not only to improve the precision of statistical analysis, but also to enrich the understanding of the underlying dynamics in complex and multidimensional systems [3]. By integrating the analytical robustness of ANOVA with the interpretive flexibility of the Neutrosophic method, the door opens to a more holistic and adaptive approach that can better model the complexities of the real world. Interest in this hybrid approach is intensified in fields such as economics, where

DOI: https://doi.org/10.54216/IJNS.250141
Received: January 24, 2024 Revised: April 19, 2024 Accepted: July 12, 2024

interactions between economic variables can be subject to multiple interpretations and significant fluctuations. In politics and social sciences, where perceptions and opinions can vary widely, the ability of the Neutrosophic method to capture these linguistic variabilities offers a robust framework for the evaluation of public policies and opinion studies. Likewise, in the field of health and medicine, where the results of treatments can vary according to multiple factors that are not always quantifiable with certainty, this methodology promises to advance towards more personalized and effective diagnoses and treatments.

The structure of the article is organized around an exhaustive review of the relevant literature, highlighting the theoretical foundations of both ANOVA and the 2-Tuple Neutrosophic method [4]. The methodology used to integrate these approaches will be detailed, providing concrete examples and case studies that illustrate their practical application in different contexts. The discussion of the results will not only focus on the analytical advantages of this hybrid model, but also on the theoretical and practical implications for future research and application in various scientific and social disciplines. In summary, this article aims to deepen the understanding and application of ANOVA and the Neutrosophic 2-Tuple method as a comprehensive tool to explore complex interactions between elements in different domains of study [5]. By integrating sound statistical principles with a flexible methodology to address linguistic ambiguity, it is hoped to provide a significant contribution to the advancement of knowledge in fields where data interpretation presents considerable challenges.

2. Relatad Works

2.1. 2-Tuple Neutrosophic Linguistic Method

The 2-Tuple Neutrosophic linguistic method emerges as an innovative paradigm in the field of set theory and mathematical logic. Developed by Professor Florentin Smarandache, this approach offers a unique perspective for addressing problems where uncertainty and ambiguity are omnipresent. Unlike traditional approaches that operate under the classical true/false paradigm, the Neutrosophic method recognizes the possibility of a third state: indeterminate. This characteristic allows us to more accurately model situations where the available information is incomplete or contradictory, as frequently occurs in decision making in complex and dynamic environments [6]. The philosophy underlying the Neutrosophic method embraces the idea that statements often cannot be clearly classified as true or false, but may contain elements of truth, falsehood, and a third category of indeterminacy. This approach not only challenges the rigidity of classical logical systems, but also provides a more flexible and adaptable theoretical framework for analyzing phenomena that escape binary categorizations. In fields such as artificial intelligence, where data interpretation often faces imprecision and variability, the Neutrosophic method presents itself as an invaluable tool to improve the accuracy of models and systems.

From a mathematical perspective, the 2-Tuple Neutrosophic method is based on set theory and fuzzy logic, expanding these disciplines by incorporating an additional degree of freedom to represent uncertainty. This translates into significant practical applications in areas such as decision making, risk assessment and information management in complex and non-deterministic environments [7]. By allowing the representation of degrees of truth, falsehood and indeterminacy in the same statement or set, this method facilitates a deeper and more nuanced understanding of reality, offering tools for more robust and realistic analysis. The usefulness of the Neutrosophic method also extends to fields as diverse as philosophy, sociology and economics, where perceptions and opinions can vary significantly and where precision in the interpretation of data is crucial to the formulation of effective policies and strategies. Its ability to integrate uncertainty formally and systematically opens new possibilities for interdisciplinary research and theoretical advancement in areas where the complexity and dynamics of human and natural systems require flexible and adaptable analytical approaches [8].

In epistemological terms, the Neutrosophic method challenges conventional notions of truth and falsity by recognizing the inherent imprecision in many judgments and propositions. This perspective invites us to reconsider how certainty is defined and interpreted in human knowledge, suggesting that absolute truth may be an unattainable goal in many contexts. Rather than seeking definitive answers, the Neutrosophic approach encourages a deeper exploration of the gray areas of information and knowledge, thus promoting a richer and more nuanced dialogue between different disciplines and theoretical perspectives. Critically, the Neutrosophic method is not only limited to an abstract tool in set theory, but has concrete and practical applications in everyday life and applied research. Its ability to handle uncertainty and ambiguity makes it a valuable resource for analyzing complex data and informing informed decisions in fields as diverse as medicine, business management, and strategic planning. By providing a formal framework for evaluating multiple points of view and degrees of certainty, the Neutrosophic method promotes a more inclusive and reflective approach to contemporary challenges facing science and society [9].

DOI: https://doi.org/10.54216/IJNS.250141
Received: January 24, 2024 Revised: April 19, 2024 Accepted: July 12, 2024

The 2-Tuple Neutrosophic linguistic method represents a significant evolution in set theory and mathematical logic by offering a more flexible and adaptive approach to modeling and understanding real-world complexity. Its ability to integrate indeterminacy as a formal category in data and decision analysis positions the Neutrosophic method as an essential tool for researchers and professionals seeking to navigate cognitive and epistemological terrains where absolute certainties are rare and ambiguity is the norm [10].

2.2. ANOVA

ANOVA analysis [16] serves as a robust methodology for unraveling the complexities of variance within data sets, encapsulating both the broad spectrum and nuanced subtleties of the observed phenomena. Through this analytical lens, we embark on a journey of exploration, delving into the heart of statistical significance to discern patterns, trends, and disparities [11].

In essence, ANOVA illuminates the landscape of variance, offering a panoramic view of the divergent paths taken by data points in different groups or treatments. It is within this mosaic of variability that we discern the subtle interplay of factors, tearing apart the threads of causality and correlation that weave the fabric of empirical reality. Meanwhile, comparison provides a lens through which we examine differences or similarities between two specific groups, enriching our understanding with a comparative perspective that reveals disparities and commonalities alike.

However, beyond the realm of statistical abstraction lies the realm of interpretive nuances, where numbers cease to be mere abstractions and assume the mantle of meaning. Here, amid the labyrinthine corridors of data interpretation, we face the perennial challenge of discerning signal from noise and the importance of spurious correlation. It is a journey fraught with epistemological dangers, where the spectrum of subjectivity takes on great importance, inviting us to navigate with caution and humility [12-14]

In essence, the ANOVA comparison is a model of statistical rigor and analytical insight, guiding us through the labyrinth of empirical research with its illuminating insights and methodological rigor. However, they are nothing more than tools in the hands of fallible interpreters, calling on us to handle them with care and discernment as we navigate the tumultuous seas of scientific inquiry.

The structure (t, i, f) consists of a space S endowed with a set of axioms (or laws) that act on it (govern it), where the space or at least one of its axioms represents uncertainty. *t* represents the degree of precision, *i* the degree of uncertainty, and f *the* degree of systematic error [15-17].

Originally, this theory was intended for applications in mathematical disciplines such as algebra, geometry, etc. However, Smarandache later realized its applicability to other scientific disciplines such as sociology. Therefore, he believes that the different points of view of all people in society lead to complex relationships in society and cause uncertainty [18].

More precisely, they are structures (t, i, f). They are defined as sociological concepts that have a certain degree of uncertainty or error for the following reasons:

1. The numerical uncertainty (or degree of uncertainty) has the form $(t, i, f) \neq (1,0,0)$, where t, i, f are numbers, intervals or subsets within a unit interval $[0, 1]$; and is the basis of the Neutrosophic social structure (t, i, f).

2. Unknown disk space due to unknown factors. My. Gram, quantity $\mathrm{NS} = \{2, 3, 5, 7, 14, \}$in which there is an unknown element and therefore the total quantity is unknown. Then we represent each element $2(1,0,0)$in a neutrosophic way and $3(1,0,0)$so on, but $\mathrm{u}(0,1,0)$.

3. Unknown space due to a partially known element., $M = \{e_1(1,0,0), e_2(1,0,0), e_3(0.8,0.1,0.1), e_4(0.2,0.3,0.6)\}$, OR$e_1$ Yoe_2 belong entirely to the whole , Mwhilee_3 There are 80% members, 10% strangers and 10% non-members. Because in other neighborhoods, $\mathrm{e}_4$their shares are 20%, 30% and 60% respectively.

Neutrosophic 2-tuples allow computing with text processing without loss of information, based on the concept of symbolic translation.

Leave$\mathrm{S} = \{\mathrm{s}_0, \mathrm{s}_1, \ldots, \mathrm{s}_\mathrm{g}\}$ is a set of linguistic terms, e.g. $\beta \epsilon [0, \mathrm{g}]$is the value within the granularity S.

Definition 1 ([19, 20, 21]) **:** The *symbolic translation* of a linguistic term $\mathrm{s}_0$is a numerical value in the interval [-0.5, 0.5], which represents the difference of information between the amount of information represented by the value β . ϵ [0, g] is obtained by a symbolic operation, and the nearest integer value $\mathrm{i} \in \{0, \ldots, \}$is the linguistic tag index (s_i), which is closest to S.

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From this concept, a model was developed to represent linguistic information using a pair of values or 2 tuples. This presentation model defines a set of functions that support operations on 2 tuples.

Definition 2 ([19, 20, 21]): Come on.$S = \{s_0, s_1, \dots, s_g\}$ is a set of linguistic terms, for example $\beta \epsilon [0, g]$, a value that represents the result of a symbolic operation . Then a set of 2 tuples representing information equivalent to β is obtained using the following function:

$\Delta: [0, g] \rightarrow S \times [-0.5, 0.5)$

$\Delta(\beta) = (s_i, \alpha)$ (1)

$i = \text{round}(\beta)$ and $\alpha = \beta - i, \alpha \in [-0.5, 0.5)$and " *round* " are common rounding operators, s_i — Index label closest to β and α That is the value of symbolic translation.

Note that $\Delta^{-1}: \langle S \rangle \rightarrow [0, g]$it is defined as $\Delta^{-1}(s_i, \alpha) = i + \alpha$. So, it is identified by its numerical value in $[0, g]$.

tuple neutrosophic linguistic numbers (2TLNN) solve the problem based on a neutrosophic set and a 2- tuple language model . (2TLS) [19, 20, 21] .

2TLNN is defined as follows [22] :

Suppose$S = \{s_0, \dots, s_g\}$ that is, 2TLS has an odd number of t+1 numbers. It is installed in$(s_T, a), (s_I, b), (S_F, c) \in$ L a, b, c ∊[0, t], where$(s_T, a), (s_I, b), (S_F, c) \in$ L they independently denote the true, unknown, and false powers of 2TLS . Then 2TLNN is defined as follows:

$l_j = \left\{(s_{T_j}, a), (s_{I_j}, b), (s_{F_j}, c)\right\}$(2)

West$0 \le \Delta^{-1}(s_{T_j}, a) \le t0 \le \Delta^{-1}(s_{F_j}, c) \le t0 \le \Delta^{-1}\left(s_{T_j}, a\right) + \Delta^{-1}\left(s_{I_j}, b\right) + \Delta^{-1}(s_{F_j}, c) \le 3t0 \le \Delta^{-1}(s_{I_j}, b) \le t$

The scoring function and accuracy allow us to classify 2TLNN [22] .

Since $l_1 = \{(s_{T_1}, a), (s_{I_1}, b), (s_{F_1}, c)\}$2TLNN is calculated in L, the estimation and precision functions are defined as follows:

$$S(l_1)=\Delta\left\{\frac{2t+\Delta^{-1}\left(s_{T_1},a\right)-\Delta^{-1}\left(s_{I_1},b\right)-\Delta^{-1}(s_{F_1},c)}{3}\right\}, \Delta^{-1}(S(l_1)) \in [0, t] \quad (3)$$

$$H(l_1)=\Delta\left\{\frac{t+\Delta^{-1}\left(s_{T_1},a\right)-\Delta^{-1}(s_{F_1},c)}{2}\right\}, \Delta^{-1}(H(l_1)) \in [0, t] \quad (4)$$

Definition 3. For 2TLNN,$l_j = \langle\left(s_{T_j}, a_j\right), \left(s_{I_j}, b_j\right), \left(s_{F_j}, c_j\right)\rangle$ (j = 1, 2,…, n) of the weight vector $w_i = (w_1, w_2, \dots, w_n)^T$satisfies the condition$w_i \in [0, 1]$ $\sum_{i=1}^{n} w_i = 1i$ Then, the following two aggregation operators are defined, which *are called* the weighted arithmetic mean of the linguistically neutrosophic. and the weighted geometric mean of the linguistically neutrosophic numbers formed by 2 tuples accordingly [23] :

$WAM(l_1, l_2, \dots, l_n) = \sum_{j=1}^{n} w_j l_j$(5)

$MGM(l_1, l_2, \dots, l_n) = \prod_{j=1}^{n} l_j^{w_j}$(6)

3. **Case study**

The study carried out in this work covered the entire population, including all guinea pig breeders in the region. Among them are 4,691 farmers from different provinces of the country.

The details of the study applicable to manufacturers are presented in Tables 1 and 2.

Table 1: Recommended research on animal welfare issues.

ARTICLE
1. How important is the welfare of animals in society to you?
2. Do you think animal welfare should be a legal priority?
3. In your opinion, to what extent do the living conditions of animals affect their health?

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Received: January 24, 2024 Revised: April 19, 2024 Accepted: July 12, 2024

4. Do you think that in your country there are sufficient regulations to protect animal welfare?
5. What is your position on the use of animals in the food industry?
6. Do you agree with animal testing in scientific research? Because?
7. In your opinion, how should animals be treated in the entertainment industry (e.g., circus, zoo)?
8. What steps will you take to improve animal welfare in your community?
9. What role do you think nonprofit organizations should play in promoting animal welfare?
10. Do you think education in animal welfare is important? How can I update?
11. What influence do you think intensive animal husbandry methods have on animal welfare?
12. Do you think wild animals can enjoy good well-being in captivity?
13. What do you think about the use of animals in cosmetic testing?
14. Do you think pets should be treated like members of the family?
15. What measures should be taken to avoid the abandonment of animals?
16. What role do you think the media plays in raising awareness about animal welfare?
17. Do you know the different animal welfare certifications for animal products?
18. What actions would you take to promote greater respect and concern for animal welfare in society?

Table 1 presents a wide range of thought-provoking research that addresses the multifaceted area of animal welfare. These questions delve into the ethical, legal and social dimensions surrounding our treatment of animals, generating introspection and debate. When reflecting on the importance of animal welfare in society, one cannot help but confront their values and beliefs regarding our responsibility towards the sentient beings with whom we share this planet. The importance of addressing animal welfare goes beyond mere moral considerations; It encompasses legal and regulatory frameworks that dictate our social norms and obligations. Should animal welfare be enshrined as a legal priority? This question forces us to contemplate the intersection of ethics and law, reflecting on whether our legal systems adequately reflect our moral imperatives toward animals. Furthermore, the impact of living conditions on animal health highlights the interconnection between the environment, welfare and ethical treatment. The way we house, feed and care for animals says a lot about our values as a society. Deliberating on the appropriateness of regulations to safeguard animal welfare forces us to confront the gaps and deficiencies of our current systems, urging us to promote and reform. When addressing these questions, one is forced to consider not only the ethical implications but also the practical steps to achieve positive change. From grassroots initiatives to the role of nonprofit organizations, from education to media advocacy, avenues to promote animal welfare abound. Ultimately, these investigations serve as catalysts for introspection, dialogue, and action, propelling us toward a more compassionate and ethically conscious society.

Table 2: Proposed study to investigate the efficiency of guinea pig farming

ARTICLE
1. How many guinea pigs do you currently have on your farm or business?
2. What is the size of your guinea pig production facility in square meters?
3. What is your favorite method of raising guinea pigs? (e.g., pen, cage, stable)
4. What food do you feed your guinea pigs? (e.g. pet foods, commercial concentrates)
5. What do you think are the main advantages of raising guinea pigs in terms of productive efficiency?

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Received: January 24, 2024 Revised: April 19, 2024 Accepted: July 12, 2024

6. What aspects of your production system do you think could be improved to increase efficiency?
7. What is the average mortality rate of guinea pigs on your farm?
8. What measures are taken to control diseases and prevent death in guinea pigs?
9. How many months will it take your guinea pig to reach its average target weight?
10. What are the main problems of guinea pig breeding in terms of productive efficiency?
11. What aspect of guinea pig nutrition do you think is most important to optimize production?
12. Do you use any technology or automated systems when raising guinea pigs? (e.g. automatic fuel system, temperature control)
13. How much do you know about the care and management of guinea pigs?
14. What strategies do you use to maximize the fertility and growth of your guinea pigs?
15. What percentage of guinea pig production is destined for the local market compared to the national or international market?
16. How do you value the quality of the product resulting from the raising of guinea pigs in your production?
17. What measures do you take to reduce production costs on your guinea pig farm?
18. What suggestions would you make to improve productive efficiency in guinea pig farming at the local or national level?

Table 2 presents an intriguing array of research poised to delve deeper into the realm of guinea pig breeding efficiency, a domain ripe for exploration and improvement. These questions, ranging from the logistical to the strategic, offer a comprehensive framework for examining the complexities of guinea pig production systems. From the practicalities of farm size and housing methods to the nuances of nutrition and disease control, each consultation invites us to look beyond the surface and uncover the underlying factors that influence production efficiency. .

As we navigate through these investigations, we find a tapestry of perspectives and practices woven into the fabric of guinea pig farming. From traditional methods to cutting-edge technologies, from local markets to global networks, the spectrum of approaches illuminates the diversity and dynamism inherent in this sector. Additionally, investigating mortality rates, growth schedules, and market dynamics reveals the complex interplay of biological, economic, and logistical factors that shape production outcomes. As we examine the challenges and opportunities inherent in guinea pig farming, we are forced to reflect not only on individual practices but also on broader systemic issues. How can we optimize nutrition to maximize growth? What innovation can we take advantage of to minimize mortality and disease? How can we balance local market demand with broader economic considerations? These questions serve as catalysts for innovation and collaboration, driving us towards a more efficient and sustainable future for guinea pig farming.

Ultimately, the proposed study summarizes not only a research effort, but a journey of discovery and transformation. It invites us to explore the terrain of guinea pig breeding with curiosity and rigor, accepting uncertainty and complexity as opportunities for growth. As we embark on this quest for greater efficiency and sustainability, let us heed the wisdom of Florentin Smarandache, who reminds us that true progress does not come from complacency, but from the relentless pursuit of knowledge and improvement.

Cronbach's alpha was at least 0.936 in both studies, so reliability was considered very high [8].

Not all people interviewed had the same access and interest in production. Some of them participate fully in the creative process, others partially and others simply own the farm. For this reason, the manufacturer's level of training is evaluated based on compliance with each of these three practices. Therefore, we combine the following neutrosophic reviews:

1. (1,0,0) **Full- time producers:** These are people whose main economic activity is the breeding and production of animals for consumption. They spend most of their time on the farm and monitor everything that happens.

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Received: January 24, 2024 Revised: April 19, 2024 Accepted: July 12, 2024

2. (0.8,0.1,0.1) **Part- time producers:** These producers have other professions or jobs besides raising livestock for consumption. They spend part of their time on the farm, sometimes in addition to their main job.

3. (0.6,0.1,0.3) **Continuous or seasonal producers:** These are people who raise livestock for consumption only at certain times of the year, such as during the breeding season or when there is market demand. In addition to livestock, they can also develop other sectors of the economy.

4. (0.4,0.1,0.5) **Casual or Hobby Producers:** This group includes those who raise animals for occasional consumption or as a hobby. They do not depend on livestock as their main source of income and can pursue other professions or interests in addition to agriculture.

Each of these values is converted to a weight value using Equation 7 [24, 25]:

$$\mathfrak{s}(w) = \frac{2+t-i-f}{3} \quad (7)$$

EITHER$w = (t, i, f)$

These weights provide information on whether each bull belongs to the group of guinea pig breeders.

In particular, everything is taken into account. $\mathrm{G} = \{\mathrm{g}_1, \mathrm{g}_2, \cdots, \mathrm{g}_{4691}\}$The same studies are taken into account in each case $g_x$because $i = 1,2,\cdots,4691$. These weights are normalized using Formula 8.

$$\overline{w}_i = \frac{w_i}{\sum_{i=1}^{4691} w_i} \quad (8)$$

Second scale $S = \{s_0, \dots, s_4\}$Thus, its components mean:

Never (s_0)

Hardly ever (s_1)

Sometimes (s_2)

Often (s_3)

Always (s_4)

Each respondent was asked to express their opinion on the three linguistic meanings present in the scale S. The first value represents the degree of agreement with the item, the second value represents the degree of uncertainty, and the third r value represents the degree of disagreement.

For example, ($\mathrm{s}_3, \mathrm{s}_2$, and s_0)it means that the respondent agrees that "Almost always" is true, is not sure that "Sometimes" is true, and is sure that "Never" is false.

Finally, the procedure to follow is summarized in Table 3:

Table 3: Data processing of the study process

PROCESSING METHODS OF DATA COLLECTED DURING THE STUDY
Input: Each interviewee is assigned a weight. $\overline{w}_i$($i = 1,2,\cdots,4691$) Membership in the Association of Guinea Pig Breeders based on the number of years of participation in the activity and its modalities. Each respondent gave three points to each item on the scale S. This means that each respondent has a partner. $\mathrm{l}_{\mathrm{ik}} = \langle (\mathrm{s}_{\mathrm{T_j}}, \mathrm{a}_\mathrm{j}), (\mathrm{s}_{\mathrm{I_j}}, \mathrm{b}_\mathrm{j}), (\mathrm{s}_{\mathrm{F_j}}, \mathrm{c}_\mathrm{j}) \rangle$I appreciate $\mathrm{k} = 1,2,\cdots,18$it $\mathrm{k} = 1,2,\cdots,36$ These are the time elements and the rest is the number of replication elements. 1. For each item, Equation 5 is applied to each weight and rating. Express it by: $\mathrm{A_k} = \langle (\mathrm{s}_{\mathrm{T_j}}, \mathrm{a}_\mathrm{j}), (\mathrm{s}_{\mathrm{I_j}}, \mathrm{b}_\mathrm{j}), (\mathrm{s}_{\mathrm{F_j}}, \mathrm{c}_\mathrm{j}) \rangle$. 2. To estimate the time spent on this activity, formula 5 is used with the same weight. $\omega_\mathrm{r} = \frac{1}{18}\mathrm{I}\ \mathrm{A_k}$because $\mathrm{k} = 1,2,\cdots,18$. Let's call it L, this is a general idea of this variable. 3. Formula 5 was used to estimate the number of copies with the same weight. $\omega_\mathrm{r} = \frac{1}{18}\mathrm{I}\ \mathrm{A_k}$because $\mathrm{k} = 18, 19,\cdots,36$. Let's call it P, this is a general idea of this variable.

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4. the same $\omega_r = \frac{1}{18}$for each $l_{ki} = \langle (s_{T_j}, a_j), (s_{I_j}, b_j), (s_{F_j}, c_j) \rangle$respondent calculated Because $k = 1,2,\cdots,18$. So talk l_{Li}.

with weight $\omega_r = \frac{1}{18}$Para, $k = 18,19,\cdots,36$equation 5 also applies . So to speak l_{Pi}.

For each interviewee, there are several (l_{Li} and l_{Pi}).

5. For each pair, (l_{Li}, l_{Pi})several numbers are calculated using equation 9:

$N = n_T - (4 - n_I) - n_F (9)$

The survey items are linked to a variable ("Reserved Duration" or "Number of Copies") that is a triple $l_{Li} = \langle s_4, s_3, s_0 \rangle$: Therefore, the value assigned to this respondent for this variable is 4-(4-3)-0 =3. Thus, for each respondent there is a pair of numerical values, one of which corresponds to "working time" and the other to "number of copies."

Spearman's Rho can be processed statistically.

Table 3 delves into the intricate data processing process within the study. From the contribution of each interviewee with their assigned weight to membership in the Guinea Pig Breeders Association based on years of participation and methodologies used, each step is meticulously outlined. Participants assign three points to each item on the S scale, which results in a series of rating pairs for each interviewee, assessing both time and number of repetitions.

By applying Equation 5 to each weight and rating of each item, estimates of time and number of copies are obtained. These values, represented by A_ k , shed light on the amount of time spent on the activity and the multiplicity of reproductions made. This process is repeated for each interviewee, producing a complex and information-rich data set.

Each pair of values, corresponding to time and number of copies, is linked to a specific variable, either "Reserved Duration" or "Number of Copies". Applying Equation 9 allows us to quantify this relationship statistically, providing deeper insight into the underlying dynamics. Finally, Spearman's Rho analysis comes full circle, offering a statistical approach to processing and understanding the nature of the correlations present in the collected data. Together, this data-processing journey immerses us in a world of detail and meaning, revealing the inherent complexities of empirical research.

The research results obtained using the methodology presented in Table 3 are as follows:

Animal welfare varies across samples, resulting in a threefold increase$\langle (s_3, 0.1634), (s_4, -0.1658), (s_0, 0.0008) \rangle$. This can be explained as follows: animal welfare is "almost always" positive, "never" negative and tends to be "always" positive.

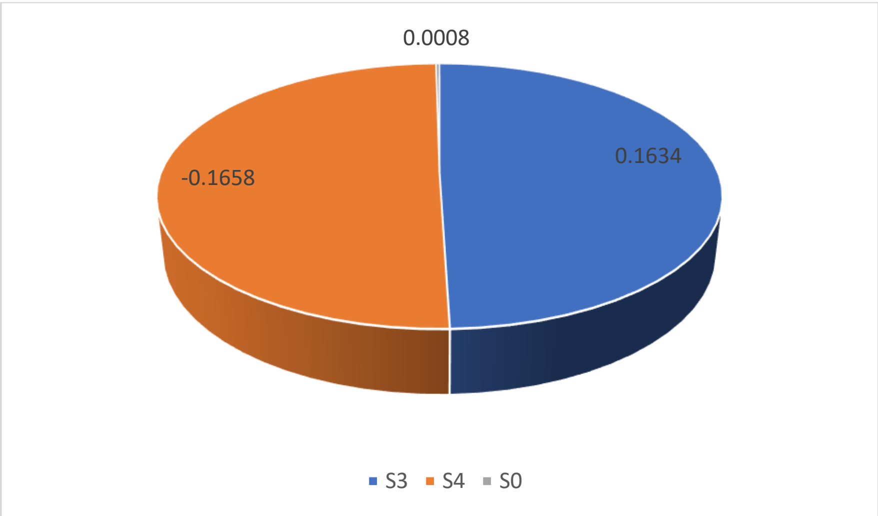

Figure 1. Statistically 1 relationship.

DOI: https://doi.org/10.54216/IJNS.250141
Received: January 24, 2024 Revised: April 19, 2024 Accepted: July 12, 2024

The production efficiency of modified guinea pigs is tripled. $\langle(s_3, -0.3226), (s_2, 0.2468), (s_0, 0.0008)\rangle$The implication is that production efficiency is "sometimes" positive, "never" negative, and "almost always" tends to be positive.

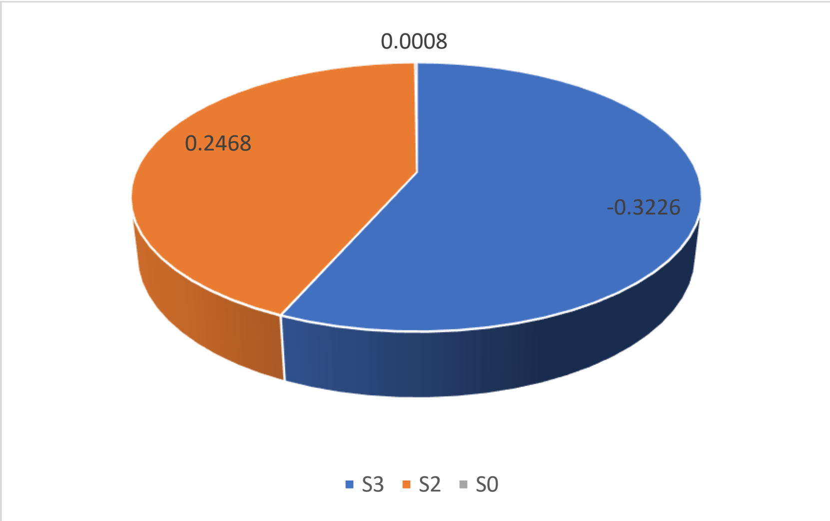

Figure 2. Statistically 1 relationship.

Spearman's rho coefficient is equal to $r_s = 0.538$[17]. This is interpreted as if there was an average positive correlation between the two variables.

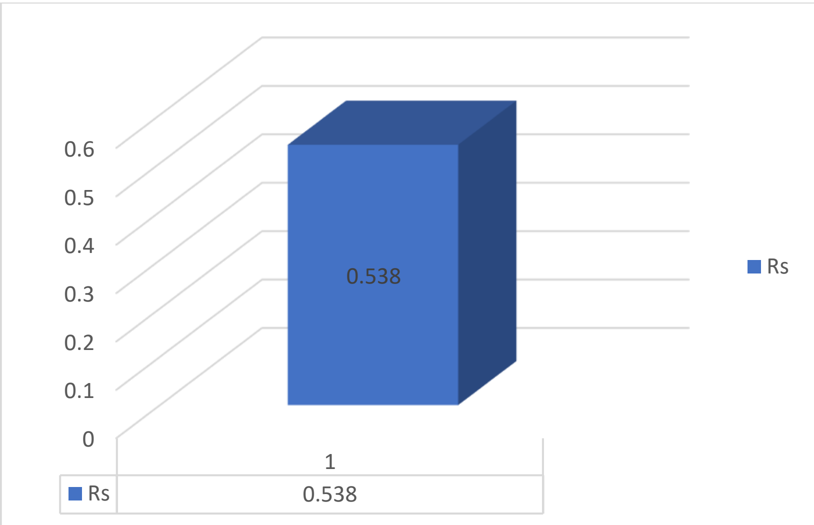

Figure 3. Spearman's rho coefficient**.**

The research results, as deduced through the methodology described in Table 3, yield interesting insights. In particular, notable variability emerges in animal welfare metrics among the sampled data, manifesting as a notable threefold increase. This phenomenon, characterized by a nuanced distribution$\langle(s_{3,0.1634}), (s_4, -0.1658), (s_{0,0.0008})\rangle$, underlines a multifaceted picture in which animal welfare predominantly shows a propensity toward positivity, rarely dips into negativity, and largely tends toward the affirmative.

Furthermore, a significant revelation emerges about the production efficiency of the modified guinea pigs, which appear to undergo a surprising threefold effect. This transformative trend

DOI: https://doi.org/10.54216/IJNS.250141
Received: January 24, 2024 Revised: April 19, 2024 Accepted: July 12, 2024

$\langle(s_3, -0.3226), (s_{2,0.2468}), (s_{0,0.0008})\rangle$outlines a scenario in which production efficiency exhibits intermittent positivity, resolutely avoids negativity, and invariably tilts toward the realm of productivity.

Furthermore, the calculated Spearman rho coefficient, recorded in $r_s = 0.538$[17], sheds light on an intriguing correlation dynamic between the variables involved. This coefficient, indicative of an average positive correlation, serves as a fundamental insight into the interaction between factors, suggesting a cohesive relationship underlying the observed phenomena.

In essence, the synthesis of these findings paints a rich tapestry of interrelated dynamics, in which animal welfare, production efficiency and correlation coefficients converge to reveal the intricate complexities inherent in the realm of guinea pig farming. These insights not only enrich our understanding of these facets, but also pave the way for informed decision-making and strategic interventions aimed at optimizing outcomes within this area.

In the present study, it was clear that food and water intake did not differ statistically during the different treatments studied ($P < 0.05$), suggesting that different amounts of bile do not affect these parameters. However, the highest consumption occurs with a housing density of 7 animals, which, according to the studies carried out, suggests the use of an area of 5 to 8 breeding guinea pigs per m $^{2.}$

Based on the above results, it was found that a complete food-based feeding system can meet all the water needs of guinea pigs. However, it is important to note that although this system ensures a full water supply, the body weight gain of guinea pigs fed this way is significantly less than that of those raised on a concentrated feeding system or a combination of both [16]. Therefore, when choosing a feeding system, both the hydration and growth of the guinea pig must be taken into account.

Reduced food intake in guinea pigs may be due to several conditions, including the animal's normal access to water. In these cases, guinea pigs can obtain water by eating food or directly from a water source. When they choose one of these options, they prefer one source over the other, but this is not necessarily detrimental. Rather, it is a natural adaptation that guinea pigs have developed to survive and thrive in their environment.

A guinea pig weighing between 500 and 800 g consumes up to 30% of its body weight in green fodder. Their needs are covered with 150 to 240 g of food per day.

In Ecuador, the most common way to house guinea pigs is in cages and pens; Studies have confirmed this and the mortality rate was 2% in indoor pools and 4% in indoor pools.

4. Conclusion

Regarding the relationship between animal welfare principles such as nutrition and productive efficiency related to health in the guinea pig production system of the Salace Academic and Experimental Center, no statistically significant differences were found, but it is highlighted that the treatment was done using this method. . The highest food and water consumption was observed in option 2, which corresponds to a density of 7 fish (6 females: 1 male). In the case of injury, based on the density of each enhanced guinea pig cell, there was no injury in any case.

The study found that a comprehensive food-based feeding system can meet all the water needs of guinea pigs. However, it is crucial to note that while this system ensures a full water supply, the body weight gain of guinea pigs fed this way is noticeably less than that of those raised on a concentrated feeding system or a combination of both. Therefore, both hydration and growth of the guinea pig should be considered when selecting a feeding regimen.

Reduced food intake in guinea pigs can be caused by a variety of conditions, including the animal's regular access to water. In such cases, guinea pigs can acquire water by consuming food or directly from a water source. When they choose either option, they favor one source over the other, but this is not necessarily detrimental. Rather, it is a natural adaptation that guinea pigs have evolved to survive and thrive in their habitat.

A guinea pig weighing between 500 and 800 g can consume up to 30% of its body weight in green fodder. Their needs are covered with 150 to 240 g of food per day. In Ecuador, the predominant method of housing guinea pigs is in cages and pens; Studies have corroborated this, with a mortality rate of 2% in closed areas and 4% in indoor pools.

Funding: This study did not receive external funding.

Conflict of interest: The authors declare that there is no conflict of interest.

DOI: https://doi.org/10.54216/IJNS.250141
Received: January 24, 2024 Revised: April 19, 2024 Accepted: July 12, 2024

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DOI: https://doi.org/10.54216/IJNS.250141
Received: January 24, 2024 Revised: April 19, 2024 Accepted: July 12, 2024