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Importance of the personality of wolves *(Canis lupus)* in managed care

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Abstract: The main purpose of this study was to define the main personality traits of two zoo-housed wolves, by evaluating the behavioral traits that remain constant in different environmental contexts. The study was conducted on two European grey wolves (Wolf A and Wolf B), housed at the Giardino Zoologico di Pistoia (Italy). The wolves were born in March 2009 at the Parco Faunistico la Torbiera (Italy) and belong to the same litter. We video-recorded 66 days divided in three observation periods: baseline period, enrichment period and fixed feeding time period. In the baseline period and enrichment periods, the food was provided by caregivers at different times during the days. For the baseline and the fixed feeding time period, we conducted 102 hours of observations (6 hours per day). During the enrichment period, we tested three types of enrichments and distributed enrichment days randomly. In this phase, we carried out 126 hours (6 hours per day). The videos were analysed with the Kinovea 0.9.5® Software. Statistical analysis was performed with the two-way ANOVA statistical test and post-hoc Tukey's multiple comparison test. The results showed a different behavioral response to various environmental contexts. Locomotion behavior was performed more by Wolf B and this difference remained constant during all phases. In enrichment period, alert and stress -related behaviors decreased in both subjects, whilst exploration and play behavior increased only for Wolf A. Furthermore, only for Wolf B was observed a reduction in locomotion. In the fixed feeding time phase, movement increased for both wolves, but alert increased for Wolf A, while it decreased for Wolf B, as well as stress-related behaviors. This study confirmed that the two subjects have consistent behavioral traits shown over the course of the three environmental conditions, with important individual differences even though the two subjects are genetically related and live together, in the same environment, since birth. The behavior analysis allowed us to define the main personality traits of the two wolves and provide key information about their needs to implement appropriate behavioral management procedures aimed at ensuring a good level of well-being.

Key Words: *Canis lupus*, behavior, personality, zoo, individuality

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Introduction

The term "personality", in animals, can be defined as individual differences in behaviour that are consistent across time and situation (Lansade et al., 2007; Réale & Dingemanse, 2012; König, 2013; Bishop et al., 2013; Sih et al., 2015; Finkemeier et al., 2018; Tebelmann & Ganslosser, 2023). The study of personality in animals has only recently gained importance in many disciplines, including zoology, biology, animal behavior, veterinary medicine and animal welfare (Jones & Gosling, 2005; Nettle & Penke, 2010; Whitham & Washbum, 2017; Delval et al., 2024). The most widely used methods to study animal personality are two: I) coding and II) rating methods (Hill et al., 2017). Coding involves observing behaviors and describing them in terms of personality traits, for example using the Five Factor Model (FFM), by which personality is defined on five main traits (Hill et al., 2017). The FFM is, thus far, the most complete and accepted method to define the structure of personality (Delval et al., 2024). Each factor is represented by two opposites dimensions: neuroticism/emotional stability, agreeableness/antagonism, extroversion/introversion among contexts and situations, openness/closure to experiences, conscientiousness/impul-

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sivity (Gosling et al., 1999). The rating method, on the other hand, requires a group of observers to make a judgment about individual traits of an animal's behavior, based on their familiarity with the subjects under study (Highfill et al., 2010). Generally, observers are provided with a list of adjectives, accompanied by their definition, which are used to classify each individual (Bishop et al., 2013). A further method for assessing certain personality traits is the use of behavioral tests in controlled environment which can highlight individual differences that would otherwise be difficult to detect (Watters & Powell, 2012). Personality and more generally individual differences in behavior, have been used to investigate issues concerning the management of zoo animals, reproduction and conservation strategies (Bishop et al., 2013). The definition of animal personality has an important role in conservation programs for wild animals, as it can help choosing the animals to be reintroduced and supports the chances of their survival (Silva & Azevedo, 2013). In fact, animals do not all respond in the same way to the environmental conditions and stimuli, but they can show variations between individuals that can affect the degree of their well-being (Tetley & O'Hara, 2012). In farm animals, personality also affect animal welfare, and this could impact on productive feature and selection (Finkermeier et al., 2018). The study of personality traits, in canine species, is considered a valid method to choose the subjects to be included in training for guide dogs or pet-therapy programs (Svartberg & Forkman, 2002). In captive animals, the study of personality can also be helpful for planning environmental enrichments programs (AZA Canid TAG, 2012), considering the different responses of individuals (Coleman, 2011). The species concerning the current study is the grey wolf (*Canis lupus* Linnaeus, 1758), which is often housed in zoos. Considering its behavioral characteristics, the controlled environment can be a source of stress for this species, due to limited spaces, excessive contact with humans, possible lack of stimuli and impossibility of implementing predatory behavior (Coelho et al., 2011; Riggio et al., 2019). The present study was developed to analyse the individual behavioral variations (personality) of a pair of wolves in different environmental contexts: baseline situation, presence of environmental enrichment and changes in feeding routine. Based on the concepts previously presented, it has been hypothesized that, due to the presence of individual differences, the two subjects would respond to the management changes, introduced during the study, by showing different behavioral patterns (hypothesis 1) and that the individual differences, related to behavioral patterns, would remain constant over time (hypothesis 2). Based on these hypotheses, the aim of the work is to define the salient personality traits of the studied subjects, by evaluating their behavioral responses to manage different environmental situations.

Materials and methods

The subjects of the study are two European grey wolves (*Canis lupus lupus*) housed at the Giardino Zoologico di Pistoia (Via Pieve a Celle Nuova, 160/A, Pistoia, 51100 Italia) since 2019. The two wolves (Wolf A and Wolf B) have characteristics of homogeneity of previous experiences, this is important for the study to exclude past experiences as the cause for behavioral differences. They are brothers of the same litter and live together since birth. The subjects were born on April 30, 2013, at the Parco Faunistico "La Torbiera" (Agrate Conturbia, NO). They are whole males easily recognisable thanks to the different colours of their coat. The two wolves are housed within a hilly fenced area of about 1350 m^2 rich in arboreal, herbaceous and shrubby vegetation. They have two dens at their disposal, represented by underground areas, and an indoor facility of 15 m^2 where they are not visible to visitors. Feeding is administered by hand by the staff, and it consists in a single daily meal. The meal consists in 5 kg of raw turkey, chicken or beef meat divided into two bowls; on Wednesdays and Saturdays 4 kg of raw meat and two frozen quails are provided. Water is always available from a tank.

The study was divided into three phases: baseline period (BAS), implementation of 3 types of

environmental enrichments period (ENR) and a period with the administration of food at a fixed time during the day (FIX).

The subject's behaviors were video recorded with a camcorder (GoPro HERO10 Black) operated by two observers from the outside of the enclosure from the same observation point, visible to the wolves. During the baseline period and the inclusion of enrichments, the wolves were fed at different times during the days. For ENR, we developed a protocol for the random administration of 3 types of environmental enrichments: dry branches with various spices (ENR1), blood and meat icicles (ENR2), mix of faeces or litter of other animals of the zoo (elephants, zebras, giraffes or ostriches) contained in paper bags (ENR3) (Bishop et al., 2013). For the baseline and the fixed feeding time period, we conducted 102 hours of focal observations (6 hours per day for 17 days). During the enrichment period, we carried out 126 hours (6 hours per day for 21 days). During the video recordings, data on environmental conditions were noted every 30 minutes: temperature (°C), relative humidity (%), intensity of environmental noise (dB) and number of visitors.

The analysis of the videos was conducted with the Kinovea 0.9.5® Software, based on an ethogram (Table 1) consisting of 11 behavioral categories. The ethogram is structured as a list of behaviors indicated by a name and/or with a detailed description and it is essential for the study of animal behavior because it outlines the purpose of the analysis (Ghaskadbi et al., 2016). All video recordings were analysed independently by 2 operators which knew the tested subjects. For each behavior category, the occurrence of the behavior and the duration in seconds were recorded. The concordance between the analysis of the two operators was verified with the statistical test of Cohen's "k" (k=0.83). We conducted the statistical analysis with the software GraphPad Prism 10.2.1 (GraphPad Software Inc., San Diego, CA, USA). We reported the data as mean and standard deviation. We tested the normality of data distribution using the Shapiro-Wilk test. The analysis of variance was carried out with the two-way ANOVA statistical test using the subjects (Wolf A and Wolf B), the periods (BAS, ENR, FIX) and their interaction as factors. The analysis of variance was followed by post-hoc analysis with the Tukey's multiple comparison test. Level of significance was set at a value of $p < 0.05$.

Behavioral Category	Code	Description	References
Resting	R	Lying down with its head on the ground, eyes can be open or closed.	Ghaskadbi et al., 2016; Way et al., 2006
Sitting	SI	Rear on the ground, with rear legs tucked in and the front legs extended	Jean-Joseph et al., 2022
Standing	ST	All four feet are on the ground with torso off the ground	Jean-Joseph et al., 2022
Locomotion	L	An individual moves around at any type of pace (walk, trot, run)	Yachmennikova & Poyarkov, 2011
Alert	AL	An individual may be sitting, standing, moving but the head is raised and eyes open. The individual looks attentively towards an interesting stimulus and moves head and ears relative to stimulus; the animal guard the environment and strongly expressed listening, and smelling	Yachmennikova & Poyarkov, 2011; Way et al., 2006
Exploring	EX	To sniff ground, objects, trees and plants, when not aimed at the acquisition of food	Way et al., 2006; Riggio et al., 2019
Eating	ET	Feeding; ingesting something	Way et al., 2006

Affiliative behavior	AB	Actor maintains proximity to an attachment figure; to sniff another wolf, lick another wolf, rub the muzzle against a wolf, rub the muzzle or body one another, greet, stand or lie close while wagging tails.	Packard, 2012; Tebelmann e Ganslosser, 2023; Riggio et al., 2019
Playing	P	Solitary play (an animal jumps alone often on environmental object, turns its body from side to side while supin, runs alone in a playful manner, runs around itself trying to catch its own tail) Social play (an animal waits in ambush a fellow that is coming and it usually jumps on it, bows in front of another as play invitation, an animal jumps on another wolf or leaps away) Object play (an animal tugs, chases, pulls to piece, kicks, shakes and bites an object with mouth or paw)	Cordoni, 2009; Riggio et al., 2019
Agonism	AG	Actor escalates a conflict in the context of a resource or threatening figure	Packard, 2012
Stress-related behavior	SB	Fright, fear, avoidance of a stress factor; an individual lays back its ears. Yawning, body shaking, lip licking, scratching	Yachmennikova e Poyarkov, 2011; Jean-Joseph et al., 2022

Table 1. Description of the behavioral categories included in the ethogram used for video analysis

Results

All behaviors included within the ethogram were observed. The behavior AGONISM (AG) was performed only in FIX and for a negligible number of times (recorded only in 4 days out of 17). Therefore, it was not examined in subsequent statistical analyses. For the behavior REST (R), from the analysis of variance, statistically significant differences among periods emerged ($p < 0.01$) but, since the resting activity could be implemented also in not visible areas, these data were not considered reliable. For the behaviors EATING (ET) and AFFILIATIVE (AB) no statistically significant differences were observed, either in the same subject between study phases (BAS, ENR and FIX), or in the same period between the two subjects (Wolf A and Wolf B). The time allocated to ALERT (AL) (Table 2) decreased in both individuals during ENR ($p < 0.05$). Wolf B implemented more AL in BAS, compared to Wolf A ($p < 0.01$). For Wolf A, on the other hand, an increase of AL in FIX was highlighted compared to Wolf B. In BAS, STRESS-RELATED BEHAVIOR (SB) (Table3) is significantly higher in both subjects than in ENR and in Wolf B's case also compared to FIX ($p <0.01$). Wolf A also engaged significantly more in EXPLORING behavior (EX), in ENR ($p < 0.01$) compared to BAS and FIX (Table 4). For Wolf B results did not show significant differences in exploring among periods, whilst we found a statistically significant difference ($p < 0.01$) between the subjects comparing ENR. For Wolf A, on the other hand, we detected a highly significant increase in PLAY (P) (Table 5) in ENR compared to the other periods ($p < 0.01$). He also played significantly more than Wolf B ($p < 0.01$). Both Wolf A ($p < 0.01$) and Wolf B ($p < 0.05$) allocated significantly more time to STAND (ST) (Table 6) behavior in FIX compared to the other phases. Wolf A expressed more this behavior in ENR and FIX ($p < 0.01$) than Wolf B. For LOCOMOTION (L) (Table 7), for Wolf B we detected a reduction in ENR ($p < 0.01$) and an increase in FIX ($p < 0.01$). For Wolf A, a highly significant increase in L was detected only in FIX ($p < 0.01$). Evaluating the differences between the subjects, statistically significant differences were noted in all phases of the study, where Wolf B always expressed more L than Wolf A ($p < 0.01$). For SITTING (SI), results showed a significant decrease for Wolf B in FIX ($p < 0.05$). Finally, Wolf B expressed more ($p < 0.01$) SI than Wolf A in BAS.

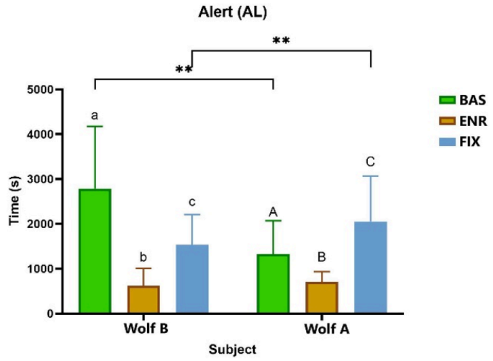

Table 2. Results divided by subjects and study periods of the time allocated to "Alert" behavior and post hoc analysis with Tukey's test:
Different lower-case = differences between periods for Wolf B
Different capital letters = differences between periods for Wolf A
Line above histograms = statistically significant differences between subjects over period (* = $p < 0.05$; ** = $p < 0.001$; *** = $p < 0.0005$; **** = $p < 0.0001$)

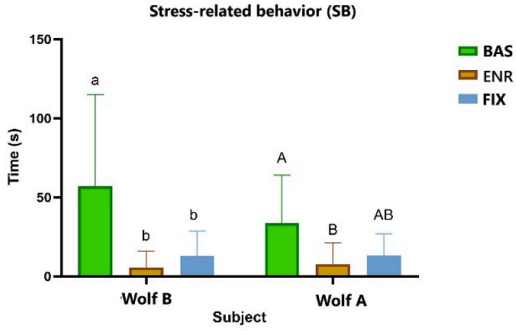

Table 3. Results divided by subjects and study periods of the time allocated to "Stress-related behavior" and post hoc analysis with Tukey's test:
Different lower-case = differences between periods for Wolf B
Different capital letters = differences between periods for Wolf A
Line above histograms = statistically significant differences between subjects over period (* = $p < 0.05$; ** = $p < 0.001$; *** = $p < 0.0005$; **** = $p < 0.0001$)

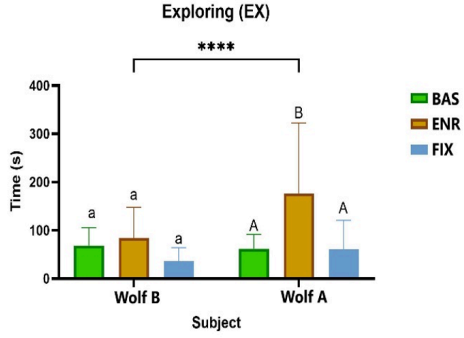

Table 4. Results divided by subjects and study periods of the time allocated to "Exploring" behavior and post hoc analysis with Tukey's test:
Different lower-case = differences between periods for Wolf B
Different capital letters = differences between periods for Wolf A
Line above histograms = statistically significant differences between subjects over period (* = $p < 0.05$; ** = $p < 0.001$; *** = $p < 0.0005$; **** = $p < 0.0001$)

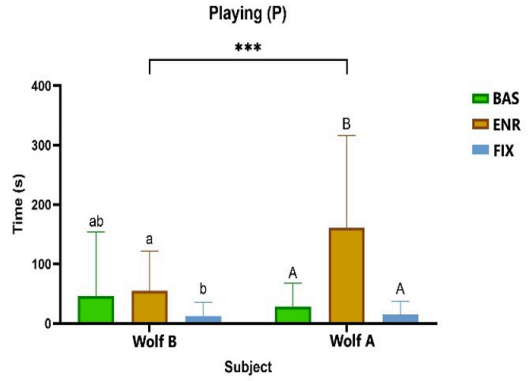

Table 5. Results divided by subjects and study periods of the time allocated to "Playing" behavior and post hoc analysis with Tukey's test:
Different lower-case = differences between periods for Wolf B
Different capital letters = differences between periods for Wolf A
Line above histograms = statistically significant differences between subjects over period (* = $p < 0.05$; ** = $p < 0.001$; *** = $p < 0.0005$; **** = $p < 0.0001$)

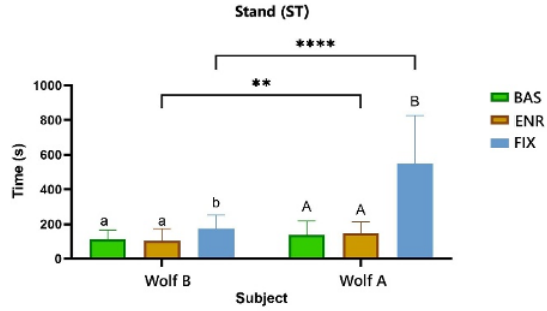

Table 6. Results divided by subjects and study periods of the time allocated to "Stand" behavior and post hoc analysis with Tukey's test:
Different lower-case = differences between periods for Wolf B
Different capital letters = differences between periods for Wolf A
Line above histograms = statistically significant differences between subjects over period (* = $p < 0.05$; ** = $p < 0.001$; *** = $p < 0.0005$; **** = $p < 0.0001$)

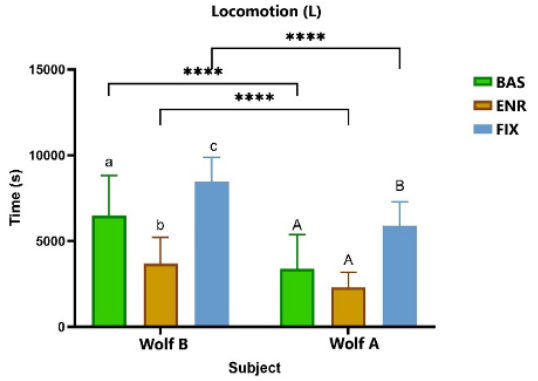

Table 7. Results divided by subjects and study periods of the time allocated to "Locomotion" behavior and post hoc analysis with Tukey's test:
Different lower-case = differences between periods for Wolf B
Different capital letters = differences between periods for Wolf A
Line above histograms = statistically significant differences between subjects over period (* = $p < 0.05$; ** = $p < 0.001$; *** = $p < 0.0005$; **** = $p < 0.0001$)

Discussion

The results showed a difference in behavior between the two subjects, suggesting a difference in personality traits, as highlighted by the changes in their behavior in the baseline condition and in response to the management changes introduced. During BAS and therefore prior to the change of management procedures, there were behavioral differences between the two subjects with Wolf B displaying a greater expression of alert (AL), locomotion (L) and sitting (SI) compared to Wolf A. The performance of these behaviors, for Wolf B, could indicate that the individual has a greater need for control over his environment. This need could be expressed with the activity of L through the patrolling of the area and with the behavior of AL to monitor the environment or check the surroundings for any potential danger. In this case we can confirm the conclusion of the study by Frézard & Le Pape (2003) where the authors highlighted how perceived control is to be considered as one of the main criteria on which to intervene to improve the welfare of wolves under human care. As a matter of fact, during FIX Wolf B reduced both stress-related behavior (SB) and AL. Wolf A, on the other hand, was more interested in the olfactory, sensory and manipulative stimuli provided as enrichments, to which he responded actively, with a statistically significant increase in exploring (EX) and playing (P) behaviors in ENR. This indicates that for Wolf A an increase in the level of well-being can be achieved with the introduction of environmental enrichments, as he has a greater need for sensory stimuli, while perceived control is not fundamental. Wolf B, although, also responded positively to the enrichments, but seemed to benefit more from the establishment of a routine that could have favoured a greater confidence in the animal. In ENR, a statistically significant reduction in AL and SB behavior was detected for both subjects, obtaining an outcome consistent with the results achieved by other studies reported in the literature (Schultz & Young, 2018; Riggio et al., 2019; Fernandez & Martin, 2021). Among the behaviors included in the ethogram, those that allowed to outline behavioral characteristics and therefore individual personality traits are lower than the number of total behaviors included in the ethogram. The behaviors that could indicate differences between the two subjects were: AL, EX, P and L. This confirms the indication of Watters & Powell (2012) according to which researchers do not need to rely on a high detailed ethogram to study animal personality. Interpreting the results of the study through the Five Factor Model of Gosling and John (1999), we can conclude that Wolf B consistently exhibited a higher level of activity, indicating a more extroverted personality. In contrast, Wolf A demonstrated greater openness to new experiences, as evidenced by increased curiosity and exploration toward the introduced enrichments. Based on these considerations, we can define Wolf B as a "re-active" subject as he prefers to exert control on his environment and wait for events, instead of implementing behaviors aimed at interacting with the sensory, olfactory and manipulative stimuli proposed. Wolf A, instead, can be considered a "pro-active" subject who does not passively react to the events but acts actively, demonstrating a greater initiative towards the environmental enrichments introduced (Delval et al., 2024). The definition of these personality traits can be very important for the decision-making process, to make appropriate management choices based on the needs of the individual animal, with the ultimate aim of ensuring high levels of wellbeing (Bishop et al., 2013). The limitation of the present study was the small sample size, but this allowed to confirm the presence of individual differences in two subjects that are siblings of the same litter, have always lived together sharing the same experiences and have been housed in the same environment. This indicates that, despite the genetic variables, the two individuals showed not only different responses to the changes introduced but also differences that were already present at the beginning of the study. We recommend, for future research, to enlarge the sample size and consider physiological indicators of stress, as for example the analysis of cortisol, to support behavioral monitoring of individual response, thus allowing the comparison between behavioral and physiological data.

Conclusions

According to our results, an animal that responds to the introduction of environmental enrichments with high levels of exploration and play can be characterized by a curious personality, open to experiences and needs adequate stimuli to improve its wellbeing as evidenced by Wolf A's behavioral response. High levels of movement and alertness can instead be indicative of a more extroverted, reactive personality with a greater need for control over their environment as shown by Wolf B. For these subjects, the creation of a routine may be recommended because it provides confidence in the animal, and it can translate into an increase in welfare. The study demonstrates the importance of assessing personality as a useful instrument to take appropriate management choices, which are fundamental for the wellbeing of animals in managed care.

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Importanza della personalità dei lupi *(Canis lupus)* nella gestione in cattività

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Sintesi

Lo scopo principale di questo studio era definire i principali tratti della personalità di due lupi ospitati in uno zoo, valutando i tratti comportamentali che rimangono costanti in diversi contesti ambientali. Lo studio è stato condotto su due lupi grigi europei (Lupo A e Lupo B), ospitati presso il Giardino Zoologico di Pistoia (Italia). I lupi sono nati a marzo 2009 presso il Parco Faunistico la Torbiera (Italia) e appartengono alla stessa cucciolata. Abbiamo videoregistrato 66 giorni suddivisi in tre periodi di osservazione: periodo di base, periodo di arricchimento e periodo di alimentazione a tempo fisso. Nel periodo di base e nei periodi di arricchimento, il cibo veniva fornito dagli operatori in momenti diversi durante il giorno. Per il periodo di base e il periodo di alimentazione a tempo fisso, abbiamo condotto 102 ore di osservazione (6 ore al giorno). Durante il periodo di arricchimento, abbiamo testato tre tipi di arricchimento e distribuito i giorni di arricchimento in modo casuale. In questa fase, abbiamo condotto 126 ore (6 ore al giorno). I video sono stati analizzati con il software Kinovea 0.9.5®. L'analisi statistica è stata eseguita con il test statistico ANOVA a due vie e il test di confronto multiplo post-hoc di Tukey. I risultati hanno mostrato una diversa risposta comportamentale a vari contesti ambientali. Il comportamento di locomozione è stato eseguito maggiormente dal Lupo B e questa differenza è rimasta costante durante tutte le fasi. Nel periodo di arricchimento, i comportamenti di allerta e correlati allo stress sono diminuiti in entrambi i soggetti, mentre i comportamenti di esplorazione e gioco sono aumentati solo per il Lupo A. Inoltre, solo per il Lupo B è stata osservata una riduzione della locomozione. Nella fase di pasto a tempo fisso, il movimento è aumentato per entrambi i lupi, ma l'allerta è aumentata per il Lupo A, mentre è diminuita per il Lupo B, così come i comportamenti correlati allo stress. Questo studio ha confermato che i due soggetti presentano tratti comportamentali coerenti nel corso delle tre condizioni ambientali, con importanti differenze individuali, sebbene i due soggetti siano geneticamente imparentati e vivano insieme, nello stesso ambiente, dalla nascita. L'analisi comportamentale ha permesso di definire i principali tratti della personalità dei due lupi e di fornire informazioni chiave sulle loro esigenze per attuare opportune procedure di gestione comportamentale volte a garantire un buon livello di benessere.