UNIVERSIDADE DE SÃO PAULO
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DOUGLAS HENRIQUE SILVA DE ALMEIDA

Regrouping stress in confined heifers
Estresse do reagrupamento em novilhas confinadas

Pirassununga

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Doctoral thesis presented to the College of Animal Science and Food Engineering of University of São Paulo in partial fulfillment of the requirements for the degree of Doctor of Science of the Animal Science graduate program.

Concentration Area:
Animal Quality and Productivity

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Profa. Dra. Cristiane Gonçalves Titto

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Dedicatory

Dedico está tese a todos os animais, criaturas de Deus, que durante este curto período do meu doutorado, receberam a minha atenção, dedicação, compromisso e respeito. Não serão em vão as noites que fiquei sem dormir, doente, preocupado com os animais, correndo contra incêndios, sofrendo nas mãos de pessoas sem caráter, passando por catástrofes e falta de alimentação nos cochos.

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Nossos resultando serão um saldo positivo para a pecuária. Também dedico este trabalho aos animais da ONG- Natureza Conecta, os quais pude ajudar com meu atendimento e atenção, durante mais de um ano de trabalho voluntário.

Dedico a vocês, criaturas de Deus.

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Epigraph

El justo sabe lo que sus animales sienten, pero el malvado nada entiende de compasión. - Provérbios 12:10.

Abstract

ALMEIDA, D. H. S. **Regrouping stress in confined heifers**. 2022. 97s. Thesis (Doctoral) – Faculdade de Zootecnia e Engenharia de Alimentos, Universidade de São Paulo, Pirassununga, 2023.

In commercial-scale confined herds, the exchange of animals in the flocks is common, regardless of color, breed, performance, sex, and category, which may be the criteria for the formation or even mixing of animals in the feeding pens. However, these exchanges interfere with the pre-established dominance hierarchy, creating situations of fights that determine the new social structure, leading to a negative impact on animal performance. The objective of this study was to evaluate aspects of feeding behavior, performance, and reactivity during regrouping in new flocks throughout the confinement cycle. Two studies were conducted at the Fernando Costa Campus (FZEA) of the University of São Paulo, Brazil. In the first study, eighty-nine Angus × Nelore heifers (315±3.4 kg, were used. The treatments consisted of four regroupings every 28 days: Regrouping 1, the animals were randomly allocated to lots (day 1, control). In regroupings 2, 3, and 4, two heifers from each lot were allocated to different lots. Animals were weighed, and their behavior was observed for three consecutive days after the three regroupings during the feedlot cycle. Agonistic interactions (fighting, head-butting with and without displacement, trough, and/or trough dispute) were quantified per flock to generate Elo classifications to identify the hierarchical status. In the second study, regroupings were performed due to the standardization of flocks by weight to evaluate the effects on animal temperament, performance, and the occurrence of disputes during feedlot confinement. Eighty-three Angus × Nelore heifers at ten months of age were confined to four stalls. After the second weighing, the heifers were subjected to three regroupings during a 1-month period (days 28, 56, and 84 of confinement), following the weight parameters, with the heifers 25% heavier allocated to lot 1 (n = 20), the animals between 26-50% of weight allocated to lot 2 (n = 21), the next 25% placed in lot 3 (n = 21), and the bottom 25% allocated to lot 4 (n = 21) at each weighing. Reactivity during weighing and exit velocity were measured before and after the third regroup. Agonistic behavior was analyzed on three consecutive days after each regrouping and on point days after the sequential days. The results were used to classify the animals into social classes (dominant, intermediate, and subordinate) by batch and Elo classifications. However, the results of the first experiment demonstrated the effects of the days after lot change on the frequency of fighting ($p < 0.01$) and head-butting with displacement ($p < 0.001$). The final social position remained the same for 54% of contemporary animals, differing substantially from that of regrouped individuals. There were higher odds of eating animals prior to regrouping 2 as well as higher odds of rumination ($p < 0.001$). Regrouping effects were observed for body weight ($p < 0.05$). Regrouping is a source of stress in confined heifers, altering the initial social structure and increasing the occurrence of agonistic interactions and conflicts, resulting in low average daily gains. In the second experiment, results showed slope values ranging from 0.55 to 0.91 in the flock hierarchy. The heifers showed a flat, non-transitive hierarchy. Animal performance was measured in terms of the average daily weight gain during the experimental period. Correlations among reactivity, daily activities, social behavior, and animal performance were evaluated. The Elo score showed a negative correlation with interactions in both regroupings (rfirst = − 0.70, $P < 0.05$, and rthird = − 0.77, $P < 0.05$). In both regroupings, there was a significant positive correlation between evaluations of Elo and degree centrality (rfirst = 053, $P < 0.05$; rthird = 0.79, $P < 0.05$), indicating that dominant animals also play a central role in agonistic interaction networks. There was a significant increase in final reactivity ($P = 0.01$) and final exit velocity, both of which were influenced by regrouping ($P = 0.01$). The number of fights differed between regroupings ($P = 0.01$), with the highest number of occurrences observed after regrouping 1 (1.51 ± 0.14). Similarly, the number of fights differed between days ($P < 0.01$), decreasing each day post-regrouping. Mean daily weight gain was greater before regrouping ($P < 0.01$). In general, regrouping is a source of stress in confined heifers, altering the initial social structure, increasing the occurrence of agonistic interactions and conflicts, and resulting in low average daily gains. However, agonistic interactions decreased over time in both experiments.

Keywords: Angus; Beef cattle; Performance; Reactivity; Social status.

Resumo

ALMEIDA, D. H. S. **Estresse do reagrupamento em novilhas confinadas**. 2022. 97f. Tese (Doutorado) – Faculdade de Zootecnia e Engenharia de Alimentos, Universidade de São Paulo, Pirassununga, 2023.

Em rebanhos confinados em escala comercial, a troca de animais nos lotes é algo comum, seja por critério de cor, raça, desempenho, sexo e categoria, vários podem ser os critérios para a formação ou até as misturas de animais nos currais de alimentação. Porém, essas trocas interferem na hierarquia de dominância pré-estabelecida, criando situações de brigas para determinação da nova estrutura social, levando a um impacto negativo sobre o desempenho dos animais. O objetivo deste estudo foi avaliar os aspectos do comportamento alimentar, desempenho e a reatividade em manejos de reagrupados em novos lotes ao longo do ciclo de confinamento. Foram dois trabalhos, realizados no *Campus* Fernando Costa (FZEA) da Universidade de São Paulo, Brasil. No primeiro estudo, oitenta e nove novilhas Angus × Nelore, 315±3,4 kg, foram confinadas. Os tratamentos consistiram em quatro reagrupamentos a cada 28 dias: Reagrupamento 1, os animais foram alocados aleatoriamente em lotes (dia 1, controle). Nos reagrupamentos 2, 3 e 4, duas novilhas de cada lote foram alocadas em um lote diferente. Os animais foram pesados e o comportamento animal foi observado durante três dias consecutivos após os tres reagrupamentos durante o ciclo de confinamento. As interações agonísticas (briga, cabeçada com e sem deslocamento, disputa de cocho e ou bebedouro) foram quantificadas por lote para gerar classificações Elo para identificar o status hierárquico. No segundo estudo, os reagrupamentos foram feitos para a padronização de lotes por peso, para avaliar os efeitos sobre o temperamento animal, desempenho e ocorrência de disputas durante o confinamento. Para isso, oitenta e três novilhas Angus × Nelore com dez meses de idade foram confinadas em 4 baias. A partir da segunda pesagem, as novilhas foram submetidas a três reagrupamentos no período de 1 mês (dias 28, 56 e 84 de confinamento), seguindo os parametros de peso, sendo as novilhas 25% mais pesadas foram alocadas no lote 1 (n = 20), os animais entre 26-50% do peso foram alocados no lote 2 (n = 21), os 25% seguintes foram colocados no lote 3 (n = 21), e os 25% inferiores foram alocados no lote 4 (n = 21) a cada pesagem. A reatividade durante a pesagem e a velocidade de saída foram medidas antes do primeiro e após o terceiro reagrupamento. O comportamento agonístico foi analisado em três dias consecutivos após cada reagrupamento e em dias pontuais após os dias sequenciais, os resultados foram usados para classificar os animais em classes sociais (dominante, intermediária e subordinada) por lote e classificação Elo. Contudo, os resultados do primeiro experimento demostraram efeitos dos dias após a troca de lote na frequência de brigas ($p < 0,01$) e cabeçadas com deslocamento ($p < 0,001$). A posição social final permaneceu a mesma para 54% dos animais contemporâneos, diferindo substancialmente daquela observada para indivíduos reagrupados. Houve maiores probabilidades dos animais comerem antes do reagrupamento 2, assim como maiores probabilidades de ruminar ($p < 0,001$). Efeitos de reagrupamento foram observados no peso corporal ($p < 0,05$). Reagrupamentos ordenados foram fontes de estresse em novilhas confinadas, alterando a estrutura social inicial, aumentando a ocorrência de interações agonísticas e conflitos, resultando em baixos ganhos médios diários. Já no segundo experimento, os resultados demosntraram valores de declividade variaram de 0,55 a 0,91 na hierarquia dos lotes. As novilhas demonstraram uma hierarquia muito plana e não transitiva. O desempenho animal foi medido em termos de ganho de peso médio diário durante o período experimental. Correlações entre reatividade, atividades diárias, comportamento social e desempenho animal foram avaliadas. O escore Elo mostrou correlação negativa com interações em ambos os reagrupamentos (rfirst = - 0,70, P < 0,05 e rthird = - 0,77, P < 0,05). Em ambos os reagrupamentos, houve uma correlação positiva significativa entre as avaliações de Elo e centralidade de grau (rfirst = 053, P < 0,05 e rthird = 0,79, P < 0,05), indicando que os animais dominantes também desempenham um papel central nas redes de interação agonística. Houve um aumento significativo na reatividade final (P = 0,01), bem como na velocidade de saída final, ambas influenciadas pelo reagrupamento (P = 0,01). O número de brigas diferiu entre os reagrupamentos (P = 0,01), sendo o maior número de ocorrências observado após o reagrupamento 1 (1,51 ± 0,14). Da mesma forma, o número de lutas diferiu entre os dias (P < 0,01), diminuindo a cada dia pós-reagrupamento. O ganho médio de peso diário foi maior antes do reagrupamento (P < 0,01). Em geral, os reagrupamentos foram fontes de estresse em novilhas confinadas, alterando a estrutura social inicial, aumentando a ocorrência de interações agonísticas e conflitos, resultando em baixos ganhos médios diários. No entanto, as interações agonísticas diminuíram ao longo do tempo nos dois experimentos.

Palavras-chave: Angus; Bovinos de corte; Desempenho; Reatividade; Status social.

Summary

1. INTRODUCTION

In intensive animal production systems, the high animal load in the system as well as the high densities are justified by the concept of productive areas, that is, the highest production in a smaller area (MONTELLI et al., 2019; BATISTA et al., 2020). Confinement finishing has acted in this sense in cattle raising, and this production system is growing. Data from 2021 show that 5.6 million cattle were finished in confined systems and that there are plans to grow this practice in the coming years (DBO, 2021). Finishing in feedlots has provided advantages for the producer, such as higher capital turnover, short cycles in the year, better animal performance, carcass yield, and bonuses for well-finished animals slaughtered at a young age (LANNA; ALMEIDA, 2005; BATISTA et al., 2020), which enables the producer to obtain the best results in zootechnical indices because of the nutritional efficiency employed and the greater sanitary control in feedlots (MACHADO et al., 2019). Currently, the confinement of cattle can be done soon after weaning, the so-called "sequestration" of calves, which prevents the calf from spending the second drought of its life on pasture, or in the phase of termination and finishing, where the animal remains confined for up to 120 days before slaughter (OLIVEIRA FILHO, 2015).

One of the disadvantages of confinement for cattle is the expense of net energy gain of the animal in activities such as competition, protection, and sodomy (KLEMM et al., 1983). Sodomy in confined cattle is described as common in the initial phases of flock formation, but it causes economic and routine problems in the feedlot, with the need to relocate frequently sodomized animals to other flocks (MACITELLI; BRAGA; PARANHOS da COSTA, 2018). This may be linked to environmental conditions, stress, overcrowding, and the increased frequency of agonistic interactions, a consequence of social disorganization in feeding pens (ULBRICH 1981).

Moreover, social disorganization in animals, or the lack of social support in herds with unstructured social structures, has a direct effect on physiological, reproductive, and immunological processes (SNOWDON, 1999). In feedlots, cattle rarely present natural social groups; that is, individuals are not family or contemporary batches throughout their productive life (PARANHOS da COSTA; COSTA and SILVA, 2007). This factor, associated with the high animal density in the feeding pens and the small supply of resources, such as feeding and drinking areas, leads to more aggressive encounters. The dominance hierarchy, which is described by Beilharz et al. (1966), is a phenomenon observed in groups, where certain individuals consistently provoke submission behaviors in other individuals, resulting in competition for food, water, shade, and other resources.

In confinement, a higher incidence of aggressive behavior, abnormal redirected behaviors (stereotypies), and watching and protection activities in confined animals has also been described (ULBRICH, 1981; HÖTZEL et al., 2005). However, when there is a defined social structure, expenditure on disputes is lower, quicker, and can be allocated to gains and the rest of the individuals (HASEGAWA et al., 1997) and the synchronization of basic activities, which could generate disputes (MOUNIER et al., 2005).

However, it is necessary to understand the effects of regrouping confined cattle at different times throughout confinement, their response, and the prevalence of these agonistic behaviors. Above all, we measured which of these effects will influence the performance, temperament, and social stability of the groups throughout the finishing of confined heifers.

1.1 Objective

This study aimed to identify social hierarchy changes in heifers in a finishing feedlot system and to investigate the general impacts of successive regroupings.

2. CHAPTER 1 - LITERATURE REVIEW

2.1. Social behavior of cattle

Naturally gregarious, cattle live in herds, with social behaviors closely linked to the structure of their group belonging (PARANHOS da COSTA; COSTA and SILVA, 2007). The formation of a social structure in commercial or wild herds reduces predation risks and provides the opportunity for new members of a herd to learn from the behaviors of the more experienced group (CARO, 1994; MORAN & DOYLE, 2015), in addition to assisting in foraging, reproduction, and shelter construction (McBRIDE, 1971; FERRAZ, 2011).

Fraser (1980) described the social structure of cattle as strong, with solid dominance and subordination relationships, linear in small groups, which may or may not be aided in horned animals of greater weight, greater age, and even previous experience in different situations (RESTLE; POLLI, 1995; DENIZ, et al., 2021). This social structure has great importance within groups because when it exists, it can promote well-being in individuals by reducing social stress (FRASER, 1980). Once the social structure is defined, it will reflect considerably on the animals' attempts to maintain homeostasis, due to the animal's lower resistance to adapting to the environment (BROOM, 1986) and to the social group it belongs to.

2.2. The onset of social interactions in cattle

As in other mammalian species, a large behavioral repertoire has been described in cattle (KLEINHAPPEL; PIKE; BURMAN, 2019), with complex and varied interactions (MAKAGON et al., 2012). However, three main behavioral categories have been presented: social behavior, reproductive behavior, and ingestive or feeding behavior (FERNANDES et. al., 2017). The social behavioral patterns of dominance and subordination, that is, the "dominance hierarchy" are described in cattle initially between the periods of 3 to 6 months of animals' life (SCHEIN; FOHRMAN, 1955), or soon after weaning (STRICKLIN et al., 1980). The association of these behaviors with the proximity of puberty periods in most species suggests a hormonal influence (MORAN; DOYLE, 2015), mainly testosterone, on the ability to dominate (PIPER, 1997). An example of this is presented in studies on testosterone induction in male and female cattle, which demonstrated a higher incidence of attacks of animals induced with testosterone in other animals, especially animals unknown to the group (BOUISSOU, 1978). In addition, they have also been reported in castrated cattle, where the frequencies of agonistic interactions between individuals are considerably lower than those in herds of whole cattle (VOLPATO; YAMAMOTO, 2011).

Natural levels of testosterone are generally higher during periods of proximity to puberty or the reproductive period, but decrease as relationships are formed and the contesting or reproductive period passes (MORAN; DOYLE, 2015). In the first instance, the animal will tend to avoid the stress of conflict; however, this cannot be avoided, and the second phase will be the fight (CANNON, 1929). In this phase, the behavioral and physiological signs such as cardiovascular responses perceptible by the increase in heart rate will be only the initial, since in other instances, the physiological responses will be of action on the hypothalamic-pituitary-adrenal axis, with signaling of the adrenal, increasing the secretion of catecholamines (adrenaline and noradrenaline), with responses of longer duration, and effects on the metabolic rates and immune and reproductive systems of individuals (MOBERG; MENCH, 2000).

Not far from these physiological responses, are also described for this period of puberty the effect of learning in cattle, influenced by the behavior of the mother and the social position she occupies in the group, as a predisposing factor that will influence both the social status of the individual and his future learning (BEILHARZ; MYLREA, 1963). The so-called social learning, has been described as the best way for the animal to save energy and time in attempts to accomplish a certain task (DARÓS, 2014). Group living is described as the best way to promote cognitive learning. Some authors have also characterized the social structure as matrilineal (PARANHOS da COSTA, COSTA, SILVA, 2007), that is, through maternal ancestry, which transmits privileges from the mother's condition or position to her offspring (MURPHEY, 1990; PARANHOS DA COSTA, 2000).

2.3. Confinement for fattening cattle

The demand for proteins of animal origin brings the need to intensify production using confinement; thus, the production and rearing of confined ruminants started to limit the expressivity of natural behaviors, characteristic of the species, in order to enhance gains, but, consequently, has promoted frustration in animals. The imposition of a series of new environments and different stressful situations, such as the natural removal of animals from pastures, restricted space, high population density in lots, new visual, olfactory, and auditory stimuli, densely packed diets, excessive grain, and small fiber, have slowed the adaptation process of animals (MALAFAIA et al., 2011).

Although feedlots in Brazil have short cycles, between 90 and 120 days (LANNA; ALMEIDA, 2005), intensification has been accompanied by restriction and reduction of available space in the feeding pens. In confined cattle, some factors have promoted greater agonistic interactions (MACITELLI, 2015), in addition to flocks with high population numbers, the restriction of space has potentiated the greater frequency and intensity of agonistic interactions, especially in flocks with more than 100 individuals, due to the difficulty of cattle in recognizing their colleagues and the social status they occupy in the flock (HURNIK, 1982; MACITELLI; BRAGA; PARANHOS da COSTA, 2018). The fact is, that even gregarious, cattle have particularities in their behavioral repertoire (BOZKURT, OZKAYA, DEW, 2006). Individual space is just one such behavior. According to Paranhos and Costa e Silva (2007), this space is characterized by the minimum distance that the animal will allow to approach other individuals in the group. According to the same authors, it is in this individual space that the basic behaviors of the species are performed, and the infiltration of this tolerance space may cause an aversive or escape response by the individual. Kondo and Hurnik (1988) described the classic patterns of bovine behavior before a conflict as noticeable, where there is visual communication through the posture of the limbs in cattle, with signs of a slightly arched tail, directed ears, and body movements, the posture that demonstrates the attention of individuals at the time of the dispute (MORAN; DOYLE, 2015).

Unplanned changes in individuals in flocks can destabilize the social structure of previously defined cattle (BOISSY; LE NEINDRE,1997; PARANHOS DA COSTA, 2000). When this procedure is performed in socially structured groups of animals, with few changes in the number of individuals, the disputes for social positions will be quick, ending within 24 h. However, when abrupt changes occur in the exchange of many animals in the flock, high frequency and duration of agonistic interactions are described, exceeding 72 h after their beginning (BOUISSOU, 1978). Regrouping or mixing of flocks within commercial herds is common to create homogeneous herds by age, performance, milk production, reproduction, and health status (BOE; FAEREVIK, 2003).

The mixing of animals from unknown purchases to form fattening lots is common in commercial properties (PARANHOS DA COSTA, 2000). The calf supply in certain periods of the year is higher, especially at the beginning of the dry period, when most producers want to terminate in the confined system (LANNA; ALMEIDA, 2005). However, regrouping and mixing of unfamiliar animals results in aggressive interactions directed mainly toward animals of low social status in the flock (BOE; FAEREVIK, 2003).

Regrouping stress has been described in various productive species, promoting different food intake rates and consumption suppression in fish (GONÇALVES DE FREITAS et al., 2019), as well as energy expenditure due to destabilization of the dominance hierarchy in pigs, fighting and redirected abnormal behaviors (HÖTZEL et al., 2005), mortality in poultry (PIPER, 1997), and weight loss in lambs (SQUIRES; DAWS, 1975).

In cattle, the frequency of regrouping individuals into structured groups may promote productive losses (PARANHOS DA COSTA, 2000). However, this practice continues to be common: once the persistence of animals during lactation is reduced, animals are allocated to lots with lower offers of concentrate to justify the low production, resulting in social disorganization (BRAKEL; LEIS, 1975) among other factors that affect milk production.

The grouping of unknown cattle increases aggression (BOZKURT, OZKAYA, DEW, 2006), social stress (BOE; FAEREVIK, 2003), reduces zootechnical indices, lowers feed consumption (BRAKEL; LEIS, 1975), water consumption (DENIZ et al., 2021), milk production (BRAKEL; LEIS, 1976, MORAN; DOYLE, 2015; HASEGAWA et al., 1997), and the quality of milk produced (MORAN; DOYLE, 2015), in addition to promoting higher sodomy frequencies (BOZKURT, OZKAYA, DEW, 2006) and increased reactivity in heifers (PARANHOS DA COSTA, 2000) because of the lack of social input from the group (TAKEDA; SATO; SUGAWARA, 2000).

2.4. Animal welfare: how to promote rational management for confined animals

During the regrouping process, the challenge is always greater for the regrouped animal than for the herd's contemporaries (BOE; FÆREVIK, 2003). However, knowledge about these effects on regrouped animals and the responses in the social interactions of the animals will allow the development of management strategies that can reduce the number of problems that occur during the animals' arrival and adaptation in the feedlot. Færevik et al. (2007) reported positive results from the practice of familiarization of cattle prior to their entry into feedlots, with the greatest increase in weight gain. The hypothesis for this lies in the likely reduction in agonistic interactions in animals that already know each other due to familiarization and diet adaptation. Macitelli et al. (2018) reported that expression results in the reduction of agonistic behavior and the formation of the dominance hierarchy in animals familiarized for 15 days before entering feeding pens.

In contrast, Mounier et al. (2005) indicated high frequencies of sexual and agonistic interactions for unfamiliar animals in feedlots due to the formation of a new social hierarchy or social destabilization. However, the use of good practices in feedlots, in addition to the understanding of behavior, may help in the practicality of daily activities on a farm. Most of the "undesirable" agonistic interactions always occur near the resources (feeders, drinkers), and are more noticeable in situations where the animals are subjected to human management, such as the grouping in the feeding corrals, within the limits of the pens, feeding squares, barns and similar (MURPHEY, 1990). It is certain that changes in the quality of the relationship between the manager and animals may be described as the first step towards the application of welfare (Paranhos da Costa et al., 2007).

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3. CHAPTER 2 - Regrouping in feedlot heifers: effects on social structure and animal performance

Manuscript submitted to Livestock Science

Abstract: This study aimed to evaluate social status changes in heifers regrouped during confinement and assess the effects of regrouping on animal performance and daily behavior. Eighty-nine Angus × Nellore heifers (Weight: 315 ± 3.4 kg), 12 months-old, were confined. Treatments consisted of four regroupings every 28 days: Regrouping 1, animals were randomly allocated into lots (day 1 of confinement, control). Regroupings 2, 3, and 4 were performed on days 32, 56, and 86 of confinement, respectively, wherein two heifers from each lot were allocated to a different lot. In each regrouping, animals were weighted, and social and daily behaviors were assessed on three consecutive days after each regrouping. Agonistic interactions were quantified per lot to generate Elo ratings to identify the hierarchical level of regrouped and contemporary animals. There was an interaction effect of regrouping and days after lot change on the total number of interactions ($p < 0.001$). There was an effect of days after lot change on the frequency of fights ($p < 0.01$) and headbutts with displacement ($p < 0.001$). The final social position remained the same for 54% of contemporary animals, differing substantially from that observed for regrouped individuals, whose maintenance of social status was only 37%. Analysis of daily behaviors revealed higher probabilities of eating ($p < 0.001$) before Regrouping 2, as well as higher probabilities of ruminating ($p < 0.001$) and drinking water ($p < 0.001$). Regrouping effects were observed on body weight ($p < 0.05$), but there were no effects on Elo rating ($p > 0.05$) based on the average daily weight gain of heifers during confinement. Ordered regroupings were sources of stress in feedlot heifers, altering the initial social structure, increasing the occurrence of agonistic interactions and conflicts, and resulting in low average daily weight gains.

Keywords: bovine sociogram; cattle hierarchy; Elo rating; fight; social network analysis

3.1. INTRODUCTION

Naturally gregarious, cattle begin to follow a social structure of dominance, or a “hierarchy of dominance,” between three and six months of age (SCHEIN; FOHRMAN, 1955). Soon after weaning, play-fighting and agonistic interactions are already noticeable between lot mates (STRICKLIN et al., 1980). In situations where lots are composed of animals with different characteristics or from different breeding systems (PARANHOS da COSTA et al., 2007), there is an increased prevalence of agonistic behaviors (KARAMFILOV, 2022), possibly due to alterations in the social structure and competition for resources (MOUNIER et al., 2005). Such interactions represent a possible source of stress for feedlot animals (KEELING; GONYOU, 2001), which may not be able to cope with these simple situations without the social support of their conspecifics (RAULT, 2012).

According to Huzzey et al. (2014), social structure and support have a strong influence on cattle performance, given that animals with low hierarchical levels tend to approach resources less frequently because of competition for trough space, resulting in reduced feeding times. Such competition leads to low performance and stress-induced health problems (BOE & FAEREVIK, 2003; BRUNO et al., 2018; DENIZ et al., 2021).

Cattle confinement systems are characterized by high productivity in small spaces (MONTELLI et al., 2019), frequent regrouping of lots for enhanced uniformity (MOUNIER et al., 2005). However, when this practice is applied indiscriminately, particularly to groups with a well-established hierarchy, regrouping can be problematic, as the introduction of new individuals may generate fights that last weeks on average and even lead to the formation of a new social organization (MURPHEY, 1990; HASEGAWA et al., 1997). Social reorganization is detrimental from an animal welfare perspective. It is known that groups with a well-defined social structure show reduced levels of aggression and increased synchronism, ensuring that all members have access to resources (FRASER, 1982).

Few studies attempted to quantify the effects of social structure changes on the quality of life, natural behavior, and performance of livestock, such as by measuring the frequency of aggressive behaviors after regrouping (BETTENCOURT, 2021). Considering the importance of uniform animals with good zootechnical indices in feedlot heifer production, this study aimed to identify social hierarchy changes in heifers in a finishing feedlot system and to investigate the general impacts of successive regroupings.

3.2. MATERIAL AND METHODS

All experimental procedures were approved by the Animal Ethics Committee (CEUA/FZEA/USP, protocol number 8806140515).

3.2.1 Facilities and handling procedures

The experiment was carried out at the Laboratory of Animal Biometeorology and Ethology, Faculty of Animal Science and Food Engineering, University of São Paulo, Brazil, between August 2019 and February 2020. The confinement system comprised 10 feedlot pens, 4 of which were used in this study. Each feedlot pen had an available area of 800 m^2, including a 130 m^2 shaded area with 80% reduction in solar radiation. Pens were equipped with 16 linear meters of concrete troughs and a circular drinker shared between two pens. All animals were handled according to rational management practices, by using flags at the coolest hours of the day, to minimize the influence of a sum of factors on the experimental hypothesis.

3.2.2. Diet

Heifers were allowed a 15-day period for diet adaptation. Feed was provided simultaneously to all lots, twice a day, at 6:00 and 15:00 h. Water was available *ad libitum*. Diets were formulated by gradually increasing the concentrate/roughage ratio according to the following strategy: days 1 to 15 of confinement, 30% concentrate; days 16 to 45, 40% concentrate; days 46 to 75, 50% concentrate; and day 76 to slaughter, 70% concentrate. This protocol allowed us to meet the nutritional requirements of heifers with a daily excess of 1500 grams of feed per animal.

3.2.3. Heifers

A total of 89 F1 Angus × Nellore crossbred heifers, aged 12 months, with a mean initial weight of 315 ± 3.4 kg, raised on pasture on the same farm, were used in the experiments. First, heifers were randomly grouped into four lots in a confinement system (lot 1, n = 22; lot 2, n = 23; lot 3, n = 21; lot 4, n = 23). The animals remained 131 days in confinement. Two animals were reallocated from each lot on three occasions, totaling six regrouped animals per lot over the experimental period (Figure 1). Regrouped animals (n = 24) were not subjected to more than one lot change to avoid penalizing some individuals more than others.

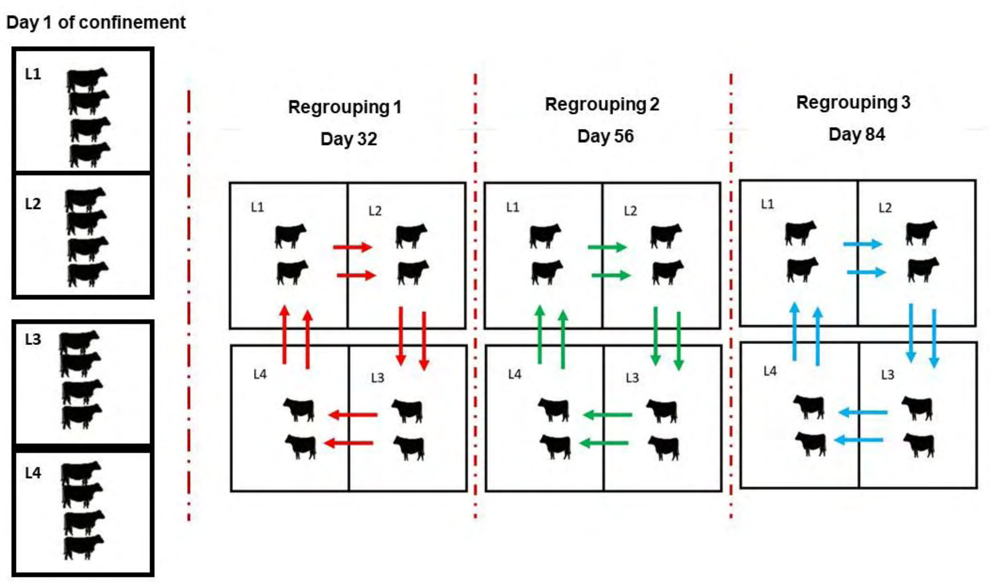


Figure 1. Scheme of the lot division strategy adopted in the first random regrouping (day 1) and subsequent ordered regroupings (days 32, 56, and 84).

3.2.4. Behavioral and daily activity observations

Behavioral observations were made from days 28 to 30 of confinement (Regrouping 1) to understand the initially defined social structure of each lot before ordered regroupings. On day 32 (Regrouping 2), two heifers of different hierarchical rank (dominant, intermediate, subordinate) were chosen at random from each lot and allocated to another lot. This same protocol was applied after Regroupings 3 and 4. Agonistic interactions and daily behaviors were observed and quantified for 3 days after each regrouping (Figure 2).

The assessment of social behaviors was performed by the collection of agonistic interactions and daily behavior (Table 1), with continuous recording of events, and focal observation of executors and recipients of agonistic behaviors. Observations were performed from 7:00 to 13:00 h and from 14:00 to 18:00 h, on 3 consecutive days after each regrouping. Observations of behaviors and daily activities were performed by trained evaluators.

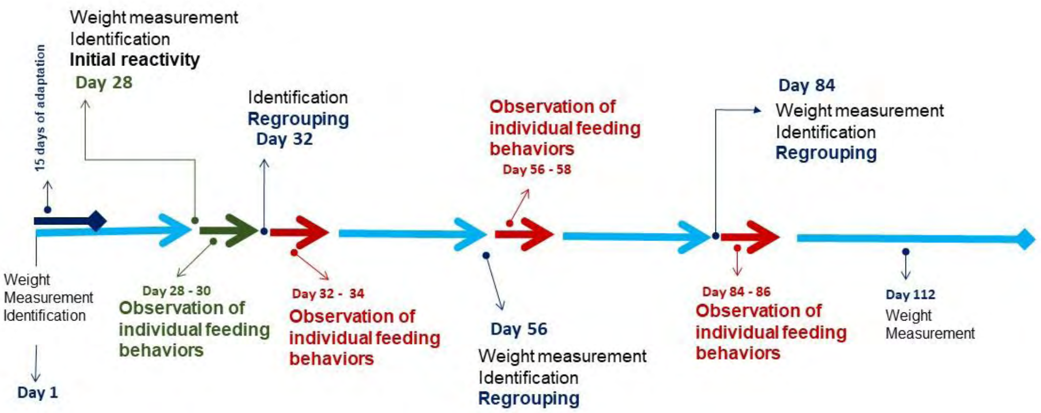


Figure 2. Timeline of observations of daily behavior, agonistic activity, and performance in feedlot heifers subjected to successive regroupings.

Table 1. Descriptors used to assess social dominance and daily behaviors during the three days following the introduction of new heifers into lots.

Behavior	**Descriptor**
Headbutt without displacement	Animal uses its head to hit another animal from the group in any part of the body. The receiver, however, does not move or give up its position.
Headbutt with displacement	Animal uses its head to hit another animal from the group in any part of the body, forcing the receiver to move or give up its position.
Fighting	Animals push their heads against each other, exerting force through their front feet. Aggression is perpetrated by both animals but results in the displacement of the receptor, who abandons the fight.
Competition for feed troughs or drinkers	An animal standing near a resource (barrier and/or trough) is displaced by another animal, who moves closer, threatens, and/or vocalizes.

Continue….

Eating	Ingesting feed with the mouth in the barrier
Ruminating	Chewing movements not accompanied by ingestion, either standing or lying down
Idle	No apparent activity, either standing or lying down
Drinking water	Drinking water from the trough
Other activities	Affiliative social activities with other members of the group or exploration of the feeding area

Source: adapted from Moran and Doyle (2015).

3.2.5. Social status

The Elo rating, originally developed by Elo (1978) to calculate the probability of chess players winning or losing a game, was used to evaluate dominance hierarchies. The Elo rating method is based on an interaction sequence, rather than on an interaction matrix, whereby ratings are continuously updated by sequentially observing interactions (NEUMANN et al., 2011).

Depending on whether the highest-ranking individual wins or loses an interaction, the ratings are updated according to the following formulas:

In the case that the highest-ranking individual wins:

$$\mathbf{Winner_{new} = Winner_{old} + (1 - \boldsymbol{p})\boldsymbol{k}}$$

$$\mathbf{Loser_{new} = Loser_{old} - (1 - \boldsymbol{p})\boldsymbol{k}}$$

In the case that the lowest-ranking individual wins:

$$\mathbf{Winner_{new} = Winner_{old} + \boldsymbol{p} \times \boldsymbol{k}}$$

$$\mathbf{Loser_{new} = Loser_{old} - \boldsymbol{p} \times \boldsymbol{k}}$$

The value of p represents the expectation of winning for the highest-rated individual, which is a function of the absolute difference in the ratings of the two interaction partners before the interaction (ALBERS; De VRIES, 2001). k is a constant that determines the number of ranking points an individual gains or losses after a single encounter. Its value is usually set between 16 and 200 and, once chosen, remains the same throughout the rating process (NEUMANN et al., 2011). Because the Elo rating method estimates competitive skills by continually updating an individual's success, it represents a cardinal success score. Thus, differences between ratings are of an interval scale, thereby allowing application of parametric statistics in subsequent analyses (NEUMANN ET al., 2011). As suggested by Sanchez-Tojar et al. (2018), the slope of the dominance hierarchy was estimated as a source of hierarchical uncertainty based on the random repeatability of the Elo rating. In the first step, interaction matrices were converted into a random sequence of possible interactions. Interaction matrices were generated with 1000 random interaction sequences. The Elo rating was then applied to each sequence, resulting in a total of 1000 scores for each individual to estimate the repeatability of the Elo ratings. The slope of a dominance hierarchy can range from very strong, where higher-ranking individuals win all conflicts (i.e., probability of 1), to very weak, where dyadic outcomes are highly unpredictable (i.e., the probability of the highest-ranking individual winning a conflict is only slightly greater than 0.5) (SANCHEZ-TOJAR et al., 2018). Thus, the Elo system is not limited to decided dominance interactions; it incorporates undecided interactions and allows detailed assessment of the hierarchy by weighting interactions according to their properties and the magnitude of the actor/receiver. This factor allows a much more precise assessment of dominance relationships (see the supplementary Table S1). Finally, the triangle transitivity (Ttri) was calculated as a stable ordering measure, as proposed by McDonald and Shizuka (2013) (see the supplementary Figures S1 to S16).

Elo scores of each lot were given in Table 2. The results of the current observations allowed identification of the social status of dominant (D), intermediate (I), and subordinate (S) animals, according to Elo ratings, in each lot for each regrouping (see the supplementary Table S2). The occurrence of such behaviors after regrouping allowed the formation of diagrams and network graphs, demonstrating the meaning of interactions (actor/receiver) and the dominance hierarchy of lots. Directed social network analyses were performed using the igraph R package (CSARDI; NEPUSZ, 2006). In directed networks, links indicate the direction of interaction between nodes (animals). The weight of the links represents the frequency of interaction between two nodes. The centrality of nodes was used as a measure of sociability, which reflects an individual's position in the network.

The status of each animal (regrouped and contemporary) was calculated using the number of animals in each lot at weighing, divided by three, referring to the hierarchical levels (D, I, S). Animals with the highest Elo rating within the lot received the status of dominant, and the same number of animals with the lowest rating received the status of subordinate.

$$\frac{\textbf{Number of animals in the lot}}{\textbf{3 (Hierarchical levels D, I, and S)}} = \textbf{Number of animals in each level}$$

Table 2. Mean, maximum, and minimum Elo ratings per lot and regrouping.

Regrouping	Lot	Mean	Max	Min
1	1	14.0593	26.448	2.97
	2	8.670238	19.806	1.017
	3	15.51428	28.123	1.034
	4	12.44152	23.354	1.41
2	1	10.5	16.859	1.907
	2	10.5	18.884	1.214
	3	12.90804	21.309	1.634
	4	11.99423	21.861	3.212
3	1	8.038733	13.893	2.74
	2	10.71221	22.973	1.017
	3	11.79488	22.638	1.547
	4	11.67427	21.941	2.994
4	1	8	14.085	2.308
	2	10	18.102	1.013
	3	12.5	22.973	2.292
	4	11.5	21.935	1.466

1, initial regrouping, before changes by hierarchical level based on observations made on day 28 of confinement. In the following regroupings (2, 3, and 4), two heifers from each lot were relocated to any other lot except their lot of origin.

3.2.6. Animal performance

Animal performance was determined as the mean daily weight gain (DWG, kg/day), calculated as the live weight gain during the period divided by the number of days between weightings. The animals were weighed upon arrival, at 15 days of diet adaptation, and four times throughout the confinement period of 131 days. The final weight was used to evaluate the total weight gain and estimate the impact of regrouping on the optimal slaughter weight.

3.2.7. Statistical analysis

Modeling of social status

Binary dependent variables were modeled using a generalized linear mixed model with maximum likelihood estimation for the binomial family and a logit link function using the R package glmTMB (BROOKS et al., 2017). Models included independent variables as fixed effects and animals (ID) as random effects. Model parameters were generated using the R package car (FOX; WEISBERG, 2019). Pairwise post hoc comparisons using *p*-values adjusted by Tukey's method were performed to compare classes of independent variables using the R package multcomp (HOTHORN et al., 2008). Differences were considered significant at $p < 0.05$. Analyses were performed using R version 4.1.2.

Performance and behavior variables

Analyses were performed to assess the effects of Elo ratings on regrouping, performance, and social and daily behaviors using the PROC MIXED procedure of SAS (SAS Inst., Inc., Cary, NC). The REPEATED command was used to model the residual covariance structure within each lot. Relationships between groupings, performance, and social and eating behaviors were assessed by estimates of residual correlations, obtained with multivariate analyses, using the PROC GLM procedure of SAS (SAS Inst., Inc., Cary, NC). Models included the fixed effects of weight on regrouping social and eating behavior, hierarchy, and trough scores before and after each regrouping and the interaction between factors on regrouping. Interaction effects were excluded from the model when non-significant at the 5% level. Associations between response variables were assessed by correlation analysis using the SAS Corr (Spearman) procedure.

3.3. RESULTS

3.3.1. Agonistic behaviors

There was an effect of regrouping (Table 3) on headbutting with displacement, fights ($p < 0.01$), and total interactions ($p < 0.01$). On the days following regrouping (Table 4), there was a significant effect on fights, headbutting with displacement, headbutting without displacement, and total interactions. No interaction effects ($p > 0.05$) were observed on the days after regrouping.

Means represent the numbers of agonistic interactions during the entire observation period. There was a total of 2359 negative interactions during the period. In the initial group (Regrouping 1), in which the hierarchy had already been established, there were 307 total interactions (including fights, headbutting with and without displacement, and trough disputes). In Regrouping 2, there were 699 total interactions; in Regrouping 3, the number of interactions decreased to 664, and, at the end of the experiment (Regrouping 4), the total number of interactions was 689.

Table 3. Daily agonistic interactions between heifers in each regrouping phase.

Agonistic behavior	*P*	Regrouping 1	Regrouping 2	Regrouping 3	Regrouping 4
Headbutt with displacement	0.02	14.3 ± 0.75b	36.2 ± 0.75a	35.4 ± 0.75a	38.5 ± 0.75a
Headbutt without displacement	0.80	3.5 ± 0.38	3.1 ± 0.38	4.8 ± 0.38	5.1 ± 0.38
Competition for troughs	0.55	5.3 ± 0.43	5.3 ± 0.43	8.9 ± 0.43	8.1 ± 0.43
Fighting	0.01	2.4 ± 0.33b	13.5 ± 0.33a	6.1 ± 0.33b	5.5 ± 0.33b
Total	0.03	25.5 ± 0.61b	58.2 ± 0.61a	55.3 ± 0.61a	57.4 ± 0.61a

Values are presented as mean ± standard error. Means within rows followed by different lowercase letters are significantly different ($p < 0.05$) by the Tukey–Kramer test.

Table 4. Daily agonistic interactions between heifers in the three days following each regrouping.

Agonistic behavior	*P*	Day 1	Day 2	Day 3
Headbutt with displacement	0.01	13.9 ± 6.56b	28.6 ± 6.56ab	50.8 ± 6.56a
Headbutt without displacement	0.02	0.8 ± 1.46b	4.8 ± 1.46ab	6.7 ± 1.46a
Competition for troughs	0.39	5.0 ± 1.91	6.8 ± 1.91	8.8 ± 1.91
Fighting	0.03	3.7 ± 1.51b	7.1 ± 1.51ab	9.8 ± 1.5a
Total	0.0014	23.6 ± 9.38b	47.5 ± 9.38ab	76.2 ± 9.38a

Values are presented as mean ± standard error. Means within rows followed by different lowercase letters are significantly different ($p < 0.05$) by the Tukey–Kramer test.

3.3.2. Transition of the social structure of regrouped animals

Prior to the ordered regroupings, 29.19% of the 24 individuals who were regrouped were dominant, 33.33% were intermediate, and 37.5% were subordinate. At the end of regroupings, the number of dominant regrouped animals increased to 62.5%, that of intermediate animals decreased to 20.8%, and that of subordinate animals decreased to 16.6%. Of the 24 animals that were regrouped, only 37.5% remained in the same dominance class.

In lot 1, heifer 38 (Elo rating = 8.50) was initially subordinate and heifer 86 (Elo rating = 17.90) was initially intermediate (Figure 3). When transferred to lot 2, however, heifer 38 became intermediate (Elo rating = 9.80) and heifer 86 (Elo rating = 7.90) became subordinate. In Regrouping 3, with the exit of two individuals and the entry of two other individuals, heifers 38 and 86 became intermediate; and, in Regrouping 4, heifer 38 became dominant (Elo rating = 14.16) and heifer 86 remained intermediate (Elo rating = 11.26).

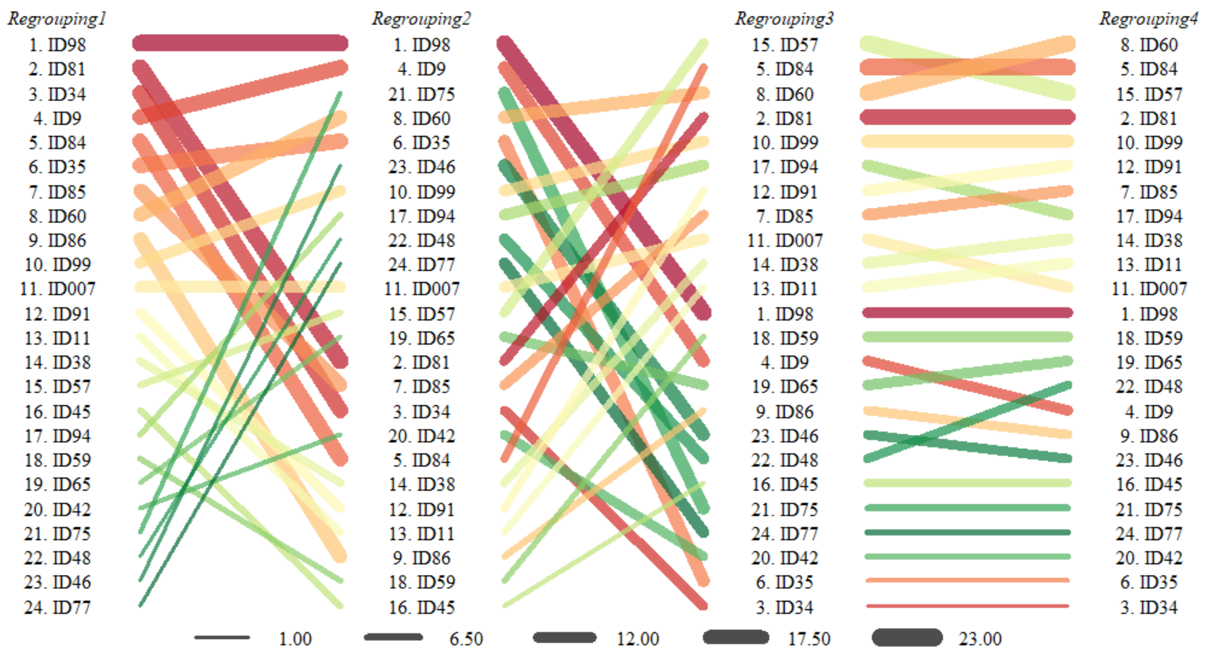


Figure 3. Graphical representation of Elo rating changes in feedlot heifers (n = 24) subjected to four regroupings. Line thickness indicates the magnitude of Elo ratings.

In lot 2, heifer 46 was initially subordinate (Elo rating = 1.40) and heifer 94, intermediate (Elo rating = 6.07). When entering lot 3 during Regrouping 2, heifers 46 and 94 became intermediate, with Elo ratings of 15.97 and 15.23, respectively. After Regrouping 3, heifer 46 remained intermediate (Elo rating = 10.67) and heifer 94 became dominant (Elo rating = 15.18). After Regrouping 4, the animals remained in the same classification, but with Elo ratings of 15.04 and 10.58, respectively.

The individuals who began in lot 3, heifers 42 and 77, had initial Elo ratings of 3.19 and 1.03, respectively. After entering lot 4, in Regrouping 2, the animals became intermediate, with Elo ratings of 14.50 and 10.50, respectively. After Regrouping 3, the animals became subordinate (Elo rating = 5.00 and 5.16, respectively), and, after the last regrouping, the animals remained subordinate, with Elo ratings of 5.17 and 5.30, respectively.

Finally, in lot 4, heifers 48 and 75, which had initial Elo ratings of 1.41 and 3.17, became dominant when regrouped to lot 1 (Elo ratings = 14.71 and 16.63, respectively). After Regroupings 3 and 4, the Elo ratings remained close to 10.59 and 7.5, respectively (Fig. 3).

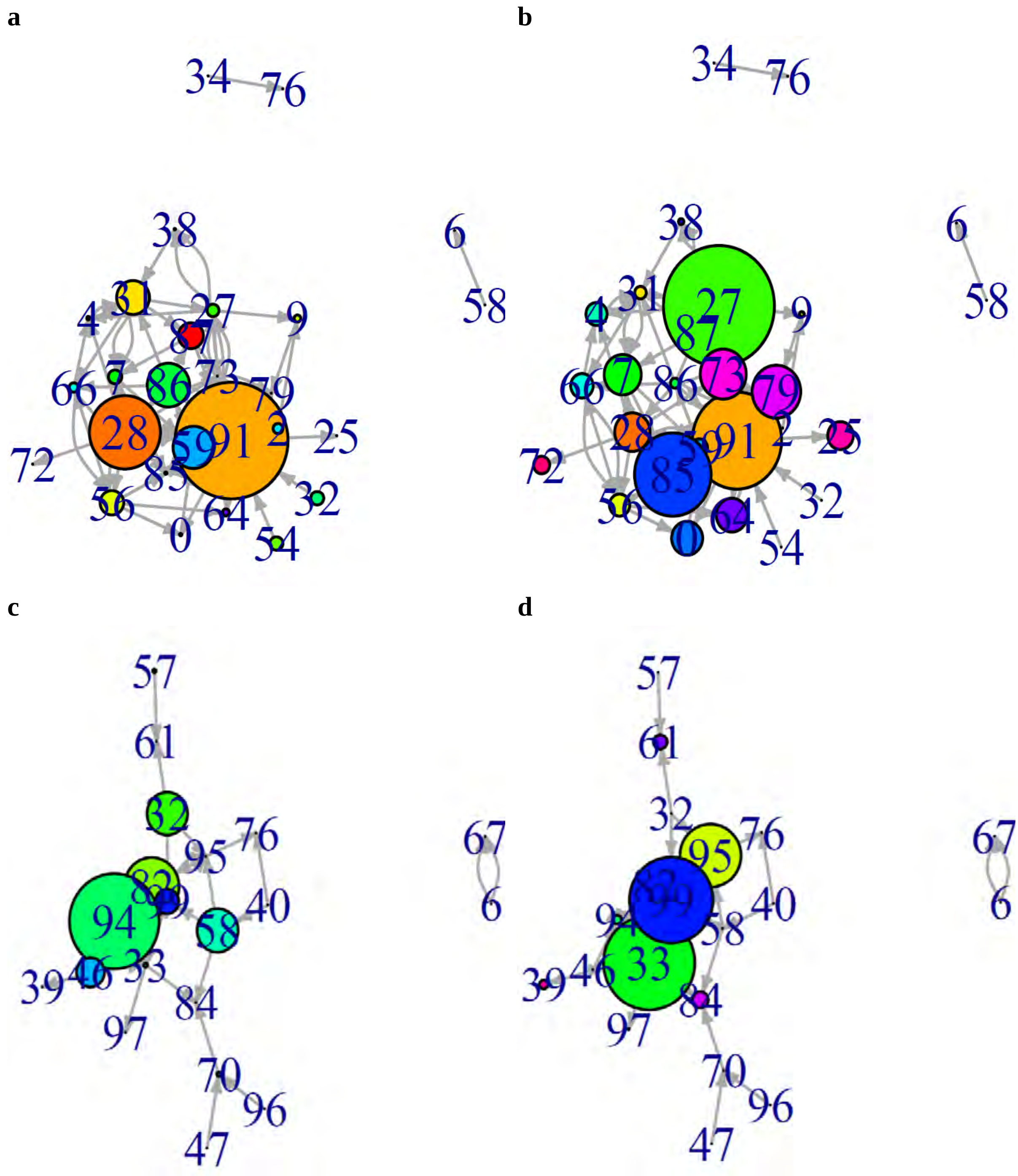
3.3.3. Social status of contemporary animals

Of the animals that were not regrouped throughout confinement, 26% were dominant, 38% were intermediate, and 36% were subordinate before ordered regroupings. At the end of the experimental period, the proportion of dominant animals decreased to 20%, that of intermediate animals increased to 42%, and that of subordinate animals increased to 38%. Thus, about 54% of contemporary individuals remained in their original hierarchical level, despite the entry of new animals from several different social classes into their lot (see supplementary Table 2).

A negative correlation was observed between initial Elo rating and live body weight during the period of stable hierarchy to day 28 of confinement ($n = 24$) ($r = -0.38$, $p = 0.07$). By contrast, a positive correlation ($r = 0.20$, $p < 0.005$) was observed between these parameters at the end of regroupings. For contemporary animals, initial Elo rating had a negative correlation with body weight during the first confinement period ($r = -0.63$, $p < 0.001$) and at the end of the experiment ($r = -0.31$, $p < 0.01$).

3.3.4. Networks of agonistic interactions

By using social network analysis, it was possible to trace the dynamics of interactions in each lot, including animals that received the most negative interactions and those that carried out these agonistic interactions. The interaction networks demonstrate the formation of dyads between specific individuals in some lots, before (Fig. 4) and after (Fig. 5) ordered regroupings.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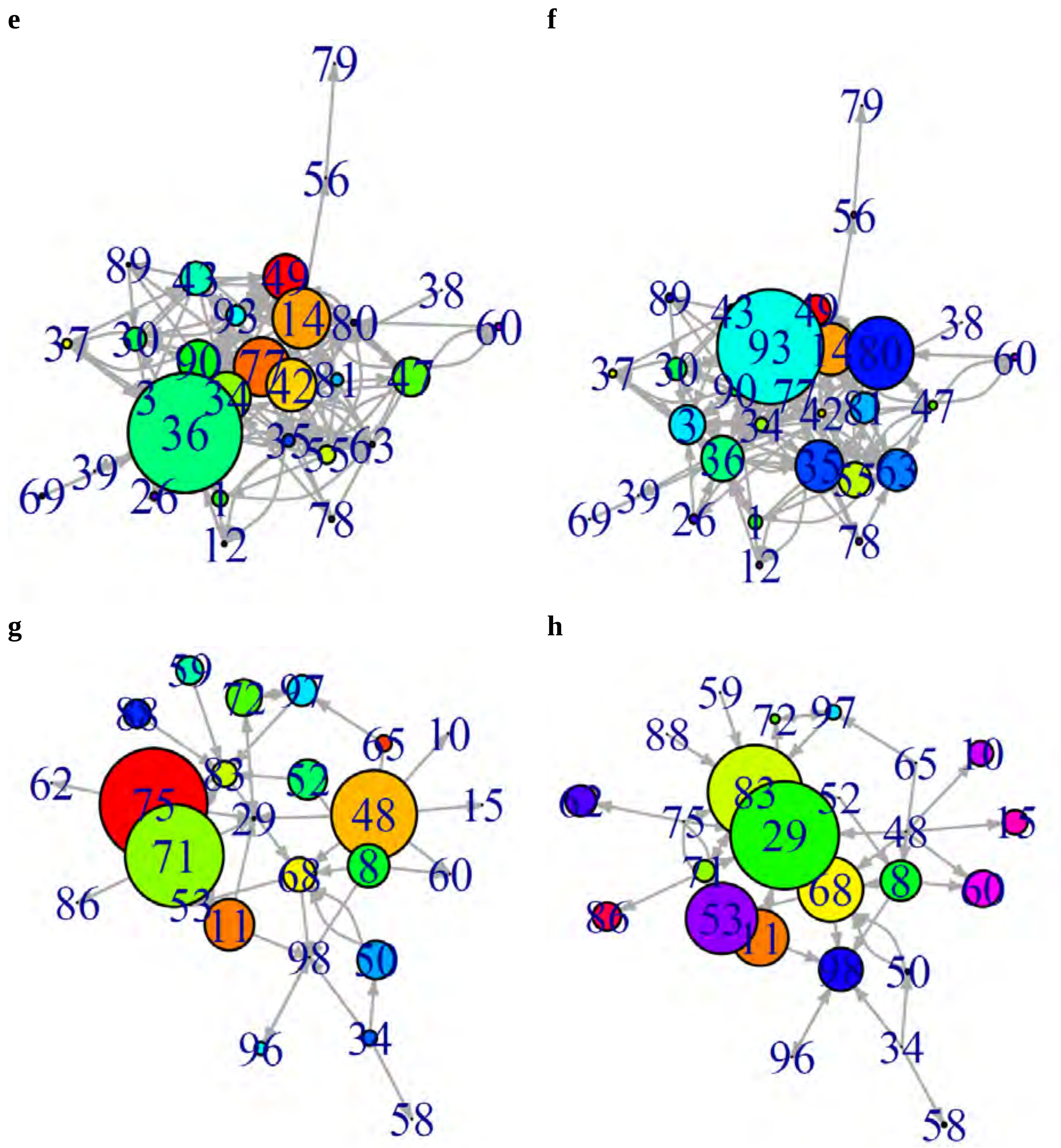
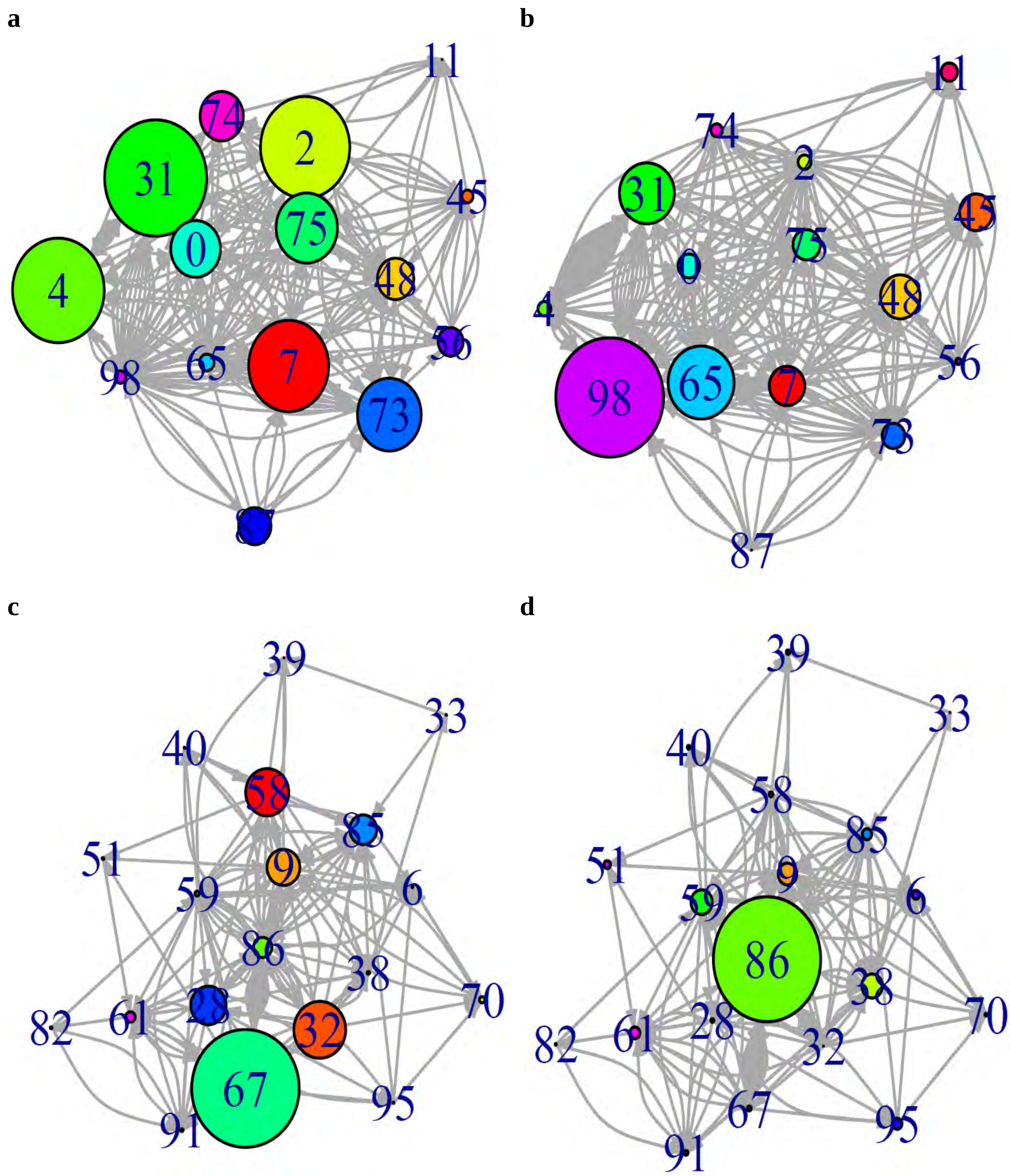


Figure 4. Diagrams illustrating the agonistic interactions within lots (a and b) 1, (c and d) 2, (e and f) 3, and (g and h) 4. Nodes represent the major (a, c, e, and g) actors and (b, d, f, and h) receivers of agonistic behaviors in the first regrouping, after organization of the social hierarchy.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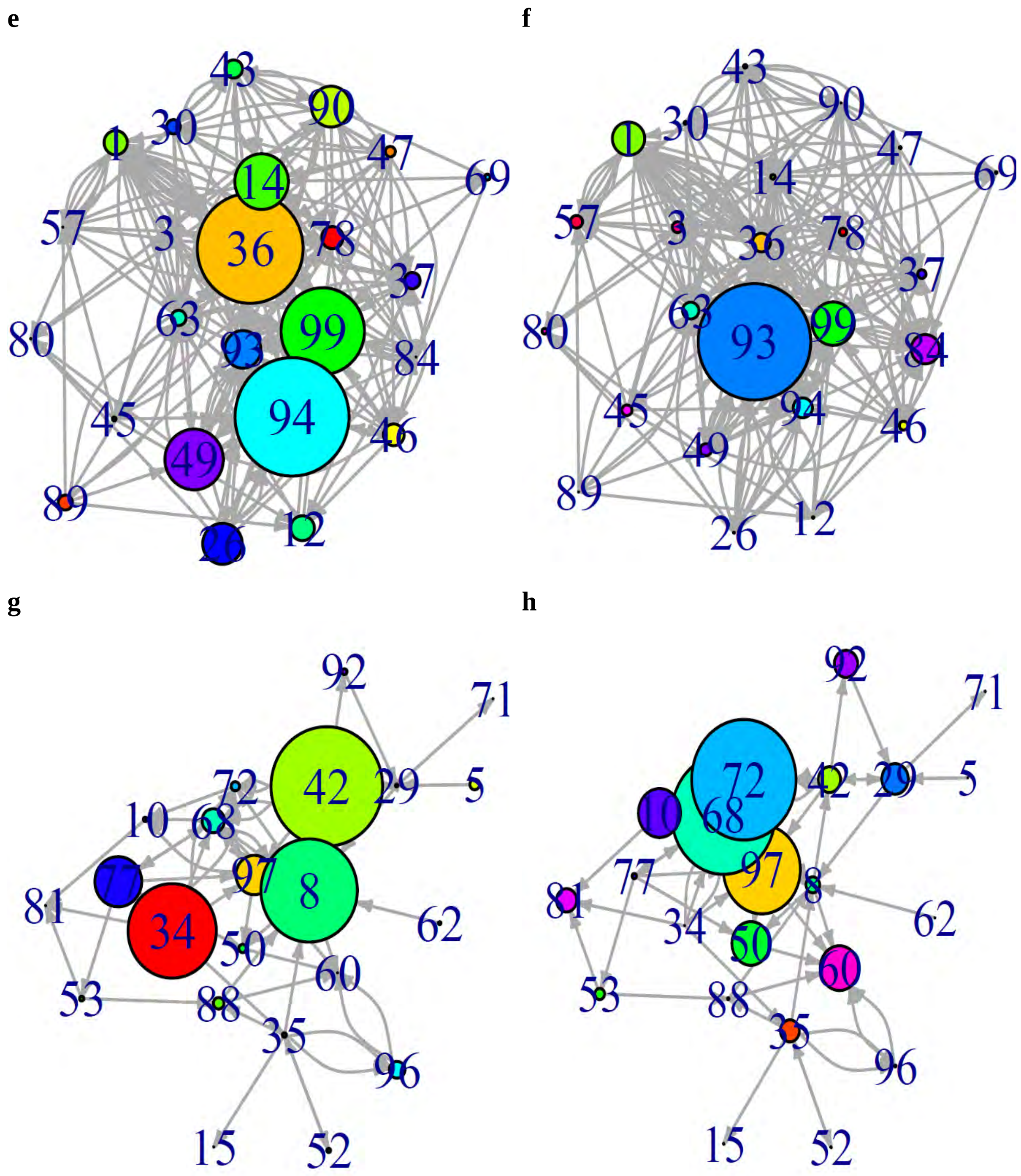

Figure 5. Diagrams illustrating the agonistic interactions within lots (a and b) 1, (c and d) 2, (e and f) 3, and (g and h) 4. Nodes represent the major (a, c, e, and g) actors and (b, d, f, and h) receivers of agonistic behaviors after the final regrouping.

Through these interactions, it was possible to identify the social position of individuals in each lot. Animals with the highest Elo ratings had the highest degree of dominance in each lot. Based on agonistic interactions, we constructed social networks for each lot and regrouping (Figs. 6, 7, 8, and 9). The size of the nodes reflects the total agonistic interactions of an individual with all other individuals within the lot. Some animals were not shown in the network due to the absence of interactions between them.

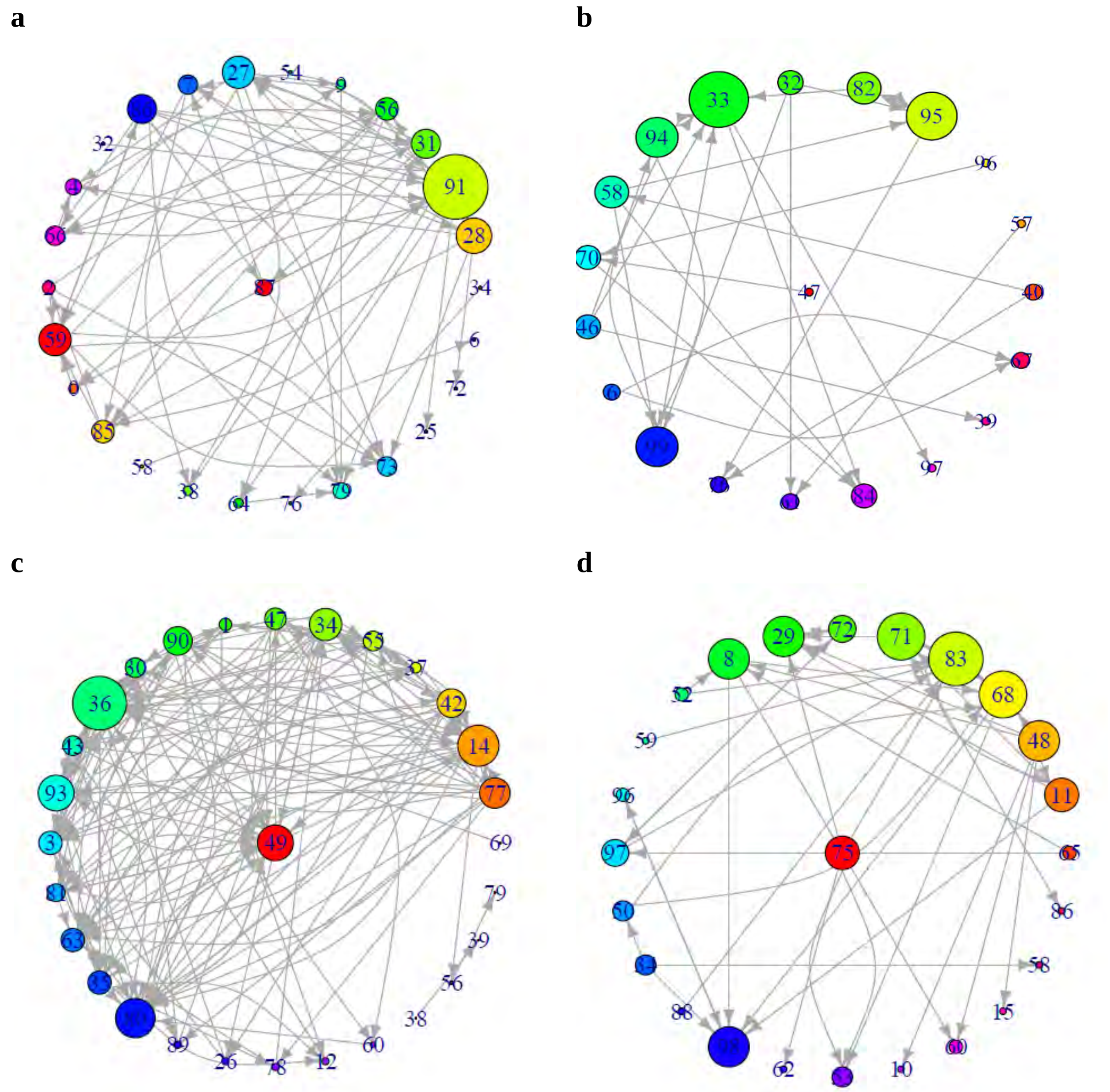

Figure 6. Graphical representation of the social network of feedlot heifers estimated from the agonistic interactions. Gray arrows indicate the direction of interactions. The size of nodes represents the social status of individuals within lots (a) 1, (b) 2, (c) 3, and (d) 4 on day 28 of confinement, after the first regrouping. Animals from different lots might be identified by the same number, given that numbering was performed using the two last digits of the Angus registration number shown on their ear tag.

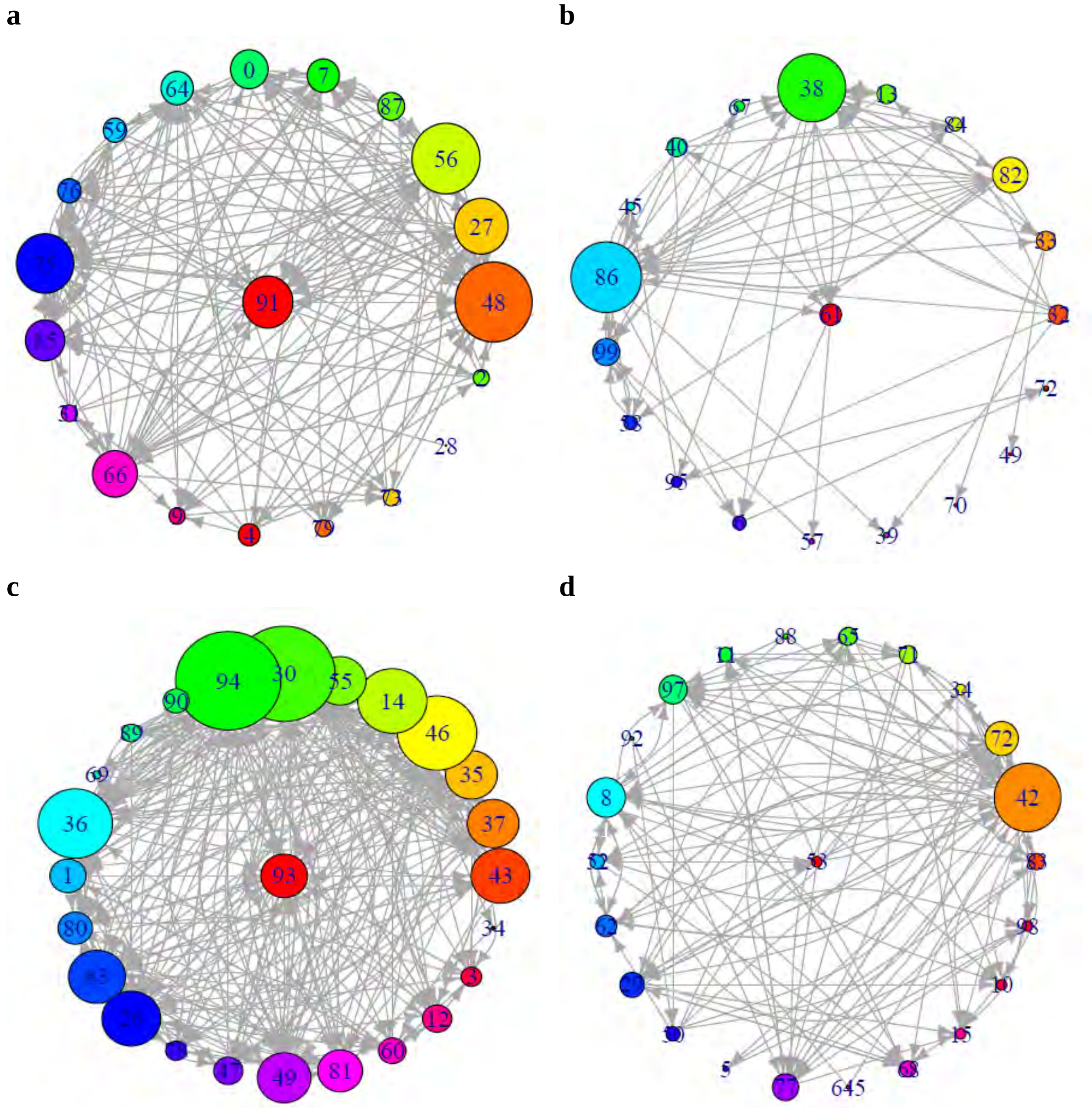

Figure 7. Graphical representation of the social network of feedlot heifers estimated from the agonistic interactions. Gray arrows indicate the direction of interactions. The size of nodes represents the social status of individuals within lots (a) 1, (b) 2, (c) 3, and (d) 4 on day 32 of confinement, after the second regrouping, where two dominant animals were reallocated to a different lot.

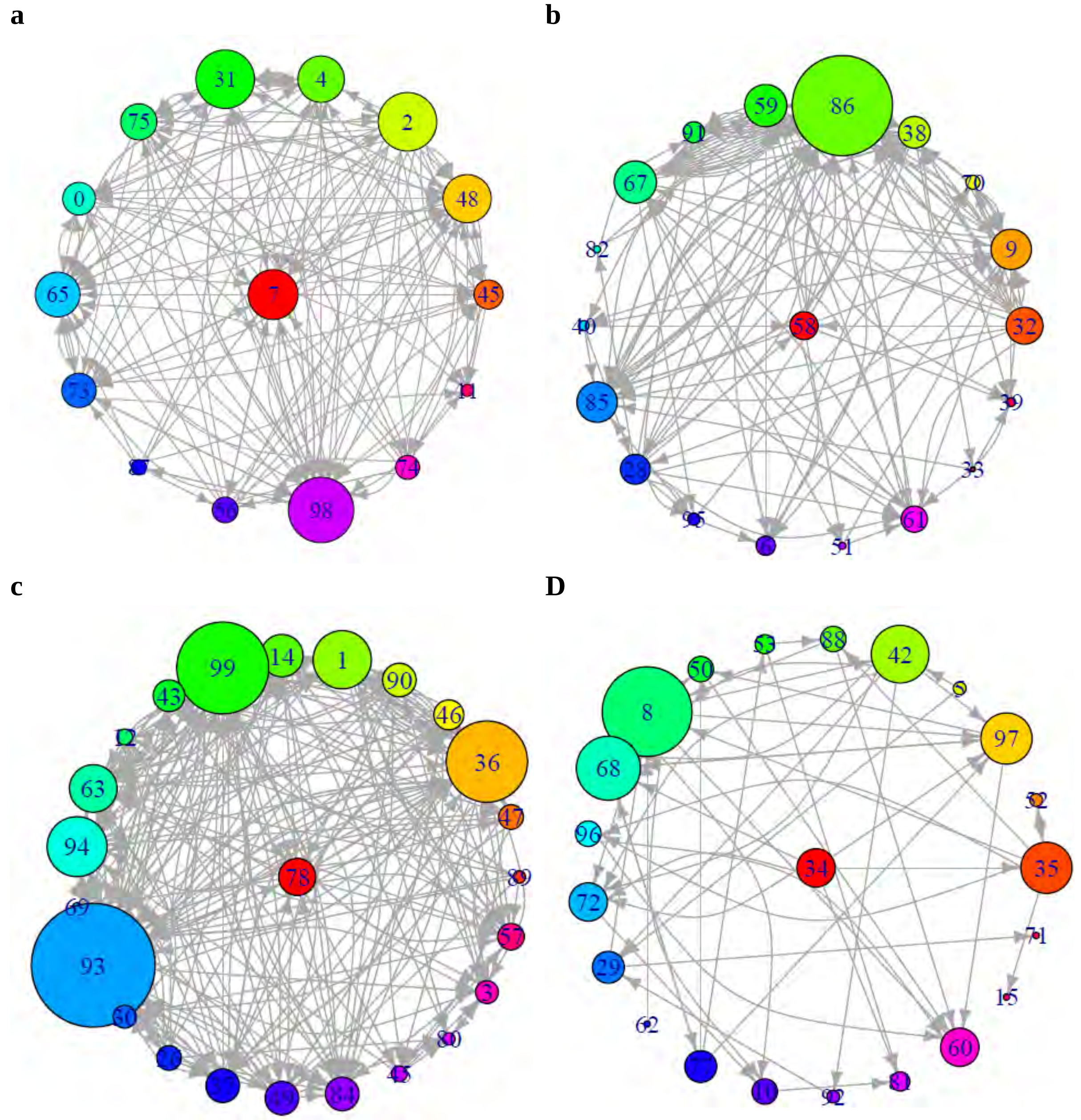

Figure 8. Graphical representation of the social network of feedlot heifers estimated from the agonistic interactions. Gray arrows indicate the direction of interactions. The size of nodes represents the social status of individuals within lots (a) 1, (b) 2, (c) 3, and (d) 4 on day 56 of confinement, after the third regrouping, where two animals with an intermediate social position were reallocated to a different lot.

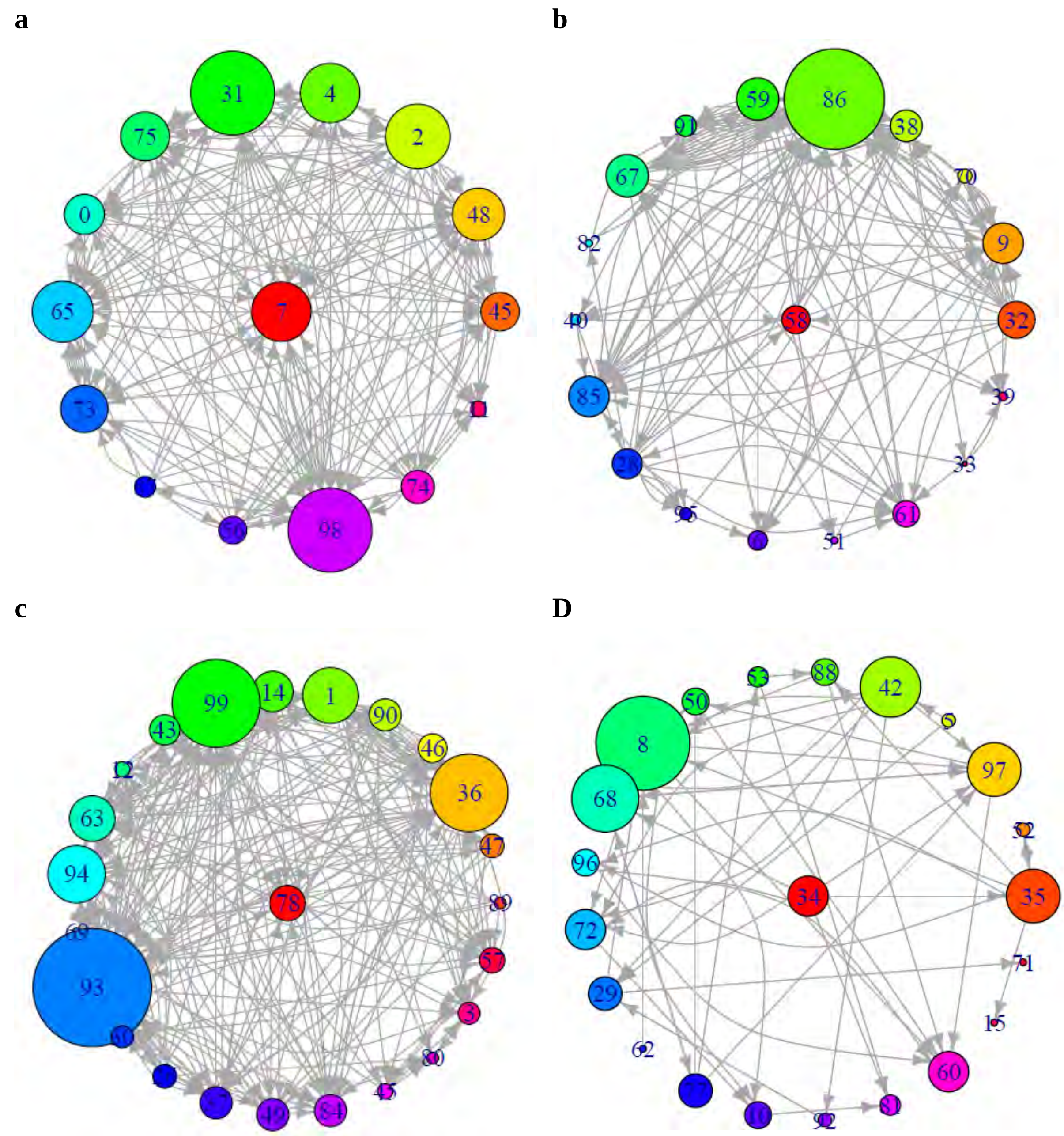

Figure 9. Graphical representation of the social network of feedlot heifers estimated from the agonistic interactions. Gray arrows indicate the direction of interactions. The size of nodes represents the social status of individuals within lots (a) 1, (b) 2, (c) 3, and (d) 4 on day 84 of confinement, after the fourth (final) regrouping, where two subordinate animals were reallocated to a different lot.

3.3.5. Daily behaviors and animal performance

There was an interaction effect of regrouping and days after lot change on the probability of drinking water ($p < 0.001$), ruminating ($p < 0.001$), being idle ($p < 0.001$), and performing other activities ($p < 0.001$). On the other hand, water consumption was not influenced by regrouping ($p > 0.05$); however, there was an effect of days after lot change on the probability of animals consuming water after regrouping ($p < 0.001$). Before ordered regrouping (Regrouping 1), animals had higher probabilities of eating ($p < 0.001$), ruminating ($p < 0.001$), and drinking water ($p < 0.001$) (Table 5). Exploratory behaviors and affiliative activity were higher after Regrouping 2 in all lots.

Table 5. Probability of daily behaviors (± standard error) observed after each regrouping.

Activity	Regrouping 1	Regrouping 2	Regrouping 3	Regrouping 4
Eating				
Day 1	0.2 ± 0.01	0.1 ± 0.01b	0.3 ± 0.10a	0.1 ± 0.01b
Day 2	0.2 ± 0.01	0.10 ± 0.01b	0.1 ± 0.01c	0.10 ± 0.01b
Day 3	0.2 ± 0.01	0.16 ± 0.01a	0.2 ± 0.01b	0.2 ± 0.01a
Ruminating				
Day 1	0.1 ± 0.01	0.05 ± 0.01b	0.03 ± 0.01b	0.05 ± 0.01c
Day 2	0.1 ± 0.01	0.05 ± 0.01ab	0.05 ± 0.01a	0.1 ± 0.01ab
Day 3	0.1 ± 822.4	0.1 ± 0.01a	0.06 ± 0.01a	0.1 ± 0.01a
Drinking water				
Day 1	0.01 ± 0.025	0.01 ± 0.003	0.005 ± 0.002	0.01 ± 0.027
Day 2	0.02 ± 0.002	0.01 ± 0.029	0.01 ± 0.003	0.01 ± 0.037
Day 3	0.02 ± 0.001	0.02 ± 0.036	0.02 ± 0.042	0.03 ± 0.004
Idle				
Day 1	0.6 ± 0.05b	0.7 ± 0.10ab	0.6 ± 0.01c	0.6 ± 0.05
Day 2	0.7 ± 0.079ab	0.6 ± 0.10b	0.7 ± 0.01b	0.7 ± 0.10
Day 3	0.7 ± 0.010a	0.7 ± 0.10a	0.9 ± 0.014a	0.7 ± 0.10
Other activities				
Day 1	0.004 ± 0.01b	0.01 ± 0.04b	0.01 ± 0.03c	0.004 ± 0.001c
Day 2	0.02 ± 0.048ab	0.02 ± 0.04ab	0.02 ± 0.04b	0.01 ± 0.002b
Day 3	0.03 ± 0.01a	0.03 ± 0.04a	0.05 ± 0.01a	0.03 ± 0.004a

Regrouping 1, initial (random) grouping; Regrouping 2, two dominant heifers relocated from each lot; Regrouping 3, two intermediate heifers relocated from each lot; Regrouping 4, two subordinate heifers relocated from each lot. For each regrouping, probabilities in the same column followed by different letters are significantly different ($p < 0.05$) by Tukey's test.

There was an effect of regrouping ($p > 0.05$) on body weight, DWG, and Elo rating, but there were no effects of Elo rating ($p > 0.05$) on body weight or DWG throughout the confinement period (Table 6).

Table 6. Body weight, daily weight gain, and Elo rating of feedlot heifers after successive regroupings.

Item	Regrouping 1	Regrouping 2	Regrouping 3	Regrouping 4
Weight	315 ± 3.45d	363 ± 3.44c	397 ± 3.44b	429 ± 3.44a
Daily weight gain	-	1.3 ± 0.03a	1.1 ± 0.03b	1.1 ± 0.03b
Elo rating	6.9 ± 1.64c	10.9 ± 0.69ab	12 ± 0.72a	13.4 ± 1.05a

Values are presented as mean ± standard error. Means in the same row followed by different lowercase letters are significantly different ($p < 0.05$) by Tukey's test.

As expected, weight increased along the feedlot ($p < 0.05$) for regrouped animals ($n = 24$) and after the second regrouping, daily weight gain decreased ($p < 0.05$) (Table 7).

Table 7. Performance variables of feedlot heifers subjected to successive regroupings.

Variable	kg
Initial weight (Regrouping 1)	319.6 ± 27.55
Weight in Regrouping 2	364.2 ± 31.46
Weight in Regrouping 3	396.1 ± 36.67
Weight in Regrouping 4	427.2 ± 43.00
Daily weight gain (Regrouping 1)	-
Daily weight gain (Regrouping 2)	1.3 ± 0.27
Daily weight gain (Regrouping 3)	1.1 ± 0.29
Daily weight gain (Regrouping 4)	1.03 ± 0.38
Total weight gain	81.1 ± 19.67
Total daily weight gain	0.96 ± 0.23

Values are presented as mean ± standard deviation

3.4. DISCUSSION

3.4.1. Aggressiveness and hierarchy in feeding pens

According to some authors, social stabilization in newly formed groups of cattle may last up to 2 weeks (MOUNIER et al., 2005) or 10 days, on average (TENNESSEN et al., 1985). Others indicate shorter periods for the stabilization of social hierarchy in cattle (BRUNO et al., 2018; OLSON et al., 2019; BETTENCOURT, 2021). In the current study, there was a lower number of agonistic interactions in the first period. The low number of interactions and dyads between animals in this first period might be because the animals were from the same farm and were initially allocated to low-density lots with a high availability of space and troughs per animal (MACITELLI, 2015).

A low number of initial trough disputes was expected, as well as an increase in disputes after regroupings. However, the number of trough disputes did not change throughout the experimental period. According to Bruno et al. (2018), in groups with a defined social structure, the few negative interactions observed are associated with individuals with low social dominance scores, who, motivated by hunger, initiate aggression against the dominant animal so that they can gain access to the trough.

3.4.2. Social networks and interaction diagrams

The theory of social networks characterizes a social group as a system of elements (HASENJAGER; DUGATKIN, 2015) interconnected by factors (NEWMAN, 2003), which, in our case, are agonistic behaviors. Newman (2003) described that the graphical representation of a social network is like a collection of nodes, where each node represents an individual and its proximity to other members of the group, according to behaviors defined and evaluated by an observer. These interactions are either bidirectional, characterized by symmetry or reciprocity of behaviors, commonly observed in affiliative behaviors, or directional, characterized by asymmetric or non-reciprocal interactions, where only one individual receives the action.

In the sociograms or network graphs, it was possible to identify relatively small circles in the center, representing animals targeted by the majority (HASENJAGER; DUGATKIN, 2015), but initially at low frequencies. After ordered regroupings, most, if not all, individuals of the lot participated in agonistic interactions, more frequently directing their attacks toward animals in the center of the network. These behaviors were more noticeable in ordered regroupings, possibly representing the establishment of a hierarchical structure. In established hierarchies, the social status is usually maintained through non-contact interactions (HUBBARD et al., 2021). In this period, bidirectional agonistic behaviors, with reciprocity between actors and receivers and inversion of such behaviors, were more evident (NEWMAN, 2003). We hypothesize that this type of reciprocity in agonistic interactions occurred because of the rupture of social support, for both regrouped and contemporary animals, as previously described for lots with well-defined structures (RAULT, 2012). According to Makagon et al. (2012), the behavior of individuals affected by social stress is perceived more intensely by some animals, leading to the emergence of new responses, influencing the behavior of the group. Thus, the group's ability to cope with stress might be affected, consequently influencing the ability of animals of different hierarchical levels to cope with taking turns at the trough and reducing disputes.

In the current study, the initial social structure (up to 28 days from the beginning of confinement) was characterized by a low frequency of agonistic behaviors; after ordered regroupings, the number of agonistic interactions increased two-fold, resulting from the entry and exit of two animals as well as the increase in dominance (Elo rating) of some regrouped and contemporary animals.

As reported by Boyland et al. (2016), in cattle, up to 57%, on average, of the initially defined social structure is repeated in the following week, but social statuses change over time, and only 17% of the initial social statuses remain unchanged in consecutive weeks. Thus, a substantial change (83%) in the sociogram structure (dominant and subordinate) may occur. In the current study, the percentage of unchanged statuses was higher among contemporary animals and lower in regrouped animals. According to Makagon et al. (2012), the exchange or removal of individuals who occupy influential positions in the network, more than others, can have a greater impact on the lot, modifying the entire social structure. Nevertheless, these modifications are expected, as it is probable that some animals will gradually ascend in the hierarchy as they reach physiological maturity (from juvenile to adult), given their greater experience (KEELING; GONYOU, 2001).

3.4.3. Daily activities and performance

In agreement with the few studies measuring the effects of regrouping on regrouped and contemporary animals, there were noticeable similarities in the general means of contemporary and regrouped animals. It was also possible to identify the effects of regrouping on the probability of ruminating and drinking water: in the initial regrouping period (days 28–30), when there was an established hierarchy in lots, these behaviors did not differ, demonstrating synchronism, as described by Mounier et al. (2005). Bettencourt (2021) referred to such effects as modifications of behavior, by which certain modifications or strategies are applied to ensure equal food intake by animals of both high and low hierarchical levels.

The probability of animals drinking water, being idle, and carrying out affiliative or exploratory activities increased after the third regrouping, suggesting greater synchronism toward the final phase of the experiment, which is possibly related to the fact that resource availability remained the same throughout the experiment.

3.5. CONCLUSION

Ordered regroupings were stressful for feedlot cattle, as they interfered with the initial social structure of animals, promoting agonistic interactions and greater changes in the social status of regrouped animals than those of contemporary individuals. After regrouping, all animals participated in disputes, influencing performance. Daily weight gain was lower than the target weight gain during confinement; as such, the optimal slaughter weight was reached 1.5 months later than expected.

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Supplementary Material

Detailed description of individual regroupings

Only Dominant Lote2 had a steepness greater than 0.90, whereas all other groups had a low steepness. Therefore, estimations of rank order were not very certain. Moreover, hierarchies were not highly transitive due to low triangular transitivity values, except for Dominant_Lote2 and Dominant_Lote7. (Table S1, Figures S1 to S16).

Table S1: Hierarchy of crossbred cattle in confinement

Lots	**Uncertainty/steepness**	**Triangle transitivity (Tria)**	**Tria P-Value**
Dominant_Lote1	0.746	-0.11	0.60
Dominant_Lote2	0.905	1.00	0.48
Dominant_Lote3	0.808	0.84	0.00
Dominant_Lote4	0.830	1.00	0.48
Inter_Lot1	0.723	0.49	0.00
Inter_Lot2	0.784	0.25	0.36
Inter_Lot3	0.599	0.38	0.00
Inter_Lot4	0.715	-0.02	0.54
Subord_Lot1	0.709	0.57	0.00
Subord_Lot2	0.779	0.46	0.03
Subord_Lot3	0.781	0.38	0.00
Subord_Lot4	0.828	0.43	0.31
Hierarchy_Final_Lote1	0.756	0.59	0.00
Hierarchy_Final_Lote2	0.779	0.46	0.03
Hierarchy_Final_Lote3	0.781	0.38	0.00
Hierarchy_Final_Lote4	0.828	0.43	0.31

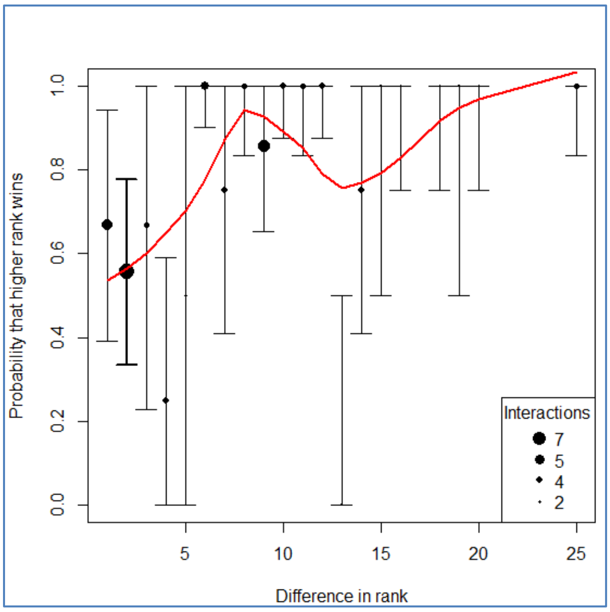

Figure S1. Dominant_Lot1. It indicates the probability of winning of the higher-ranked individual based on the difference in rank between the two contestants.

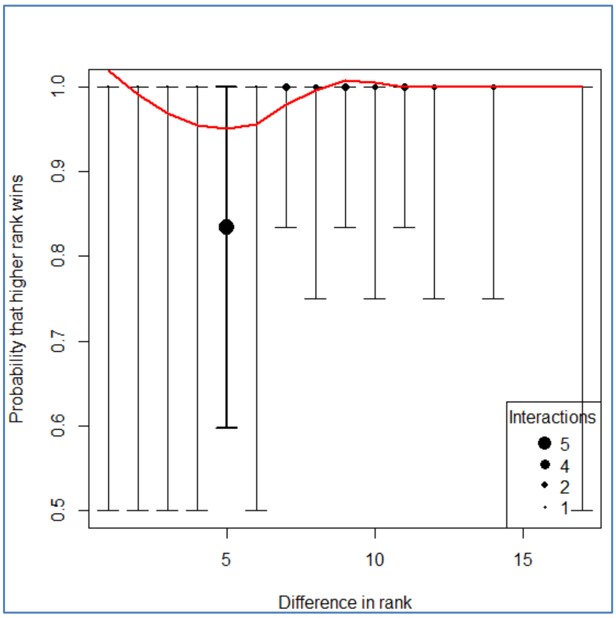

Figure S2. Dominant_Lot2. It indicates the probability of winning of the higher-ranked individual based on the difference in rank between the two contestants.

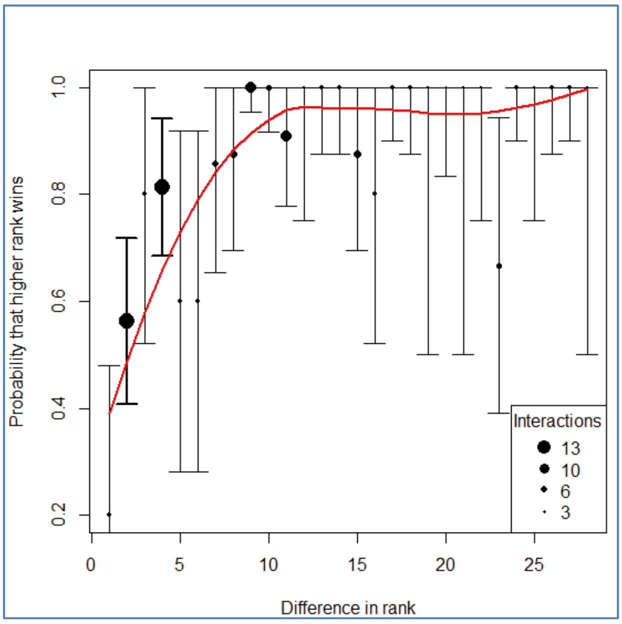

Figure S3. Dominant_Lot3. It indicates the probability of winning of the higher-ranked individual based on the difference in rank between the two contestants.

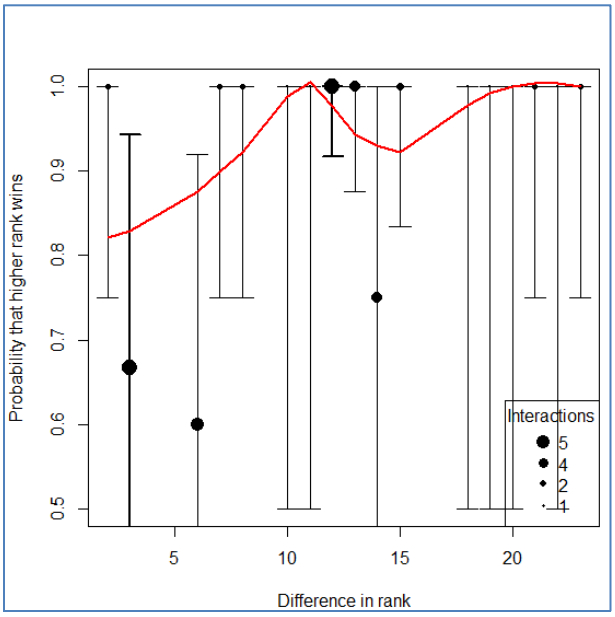

Figure S4. Dominant_Lot4. It indicates the probability of winning of the higher-ranked individual based on the difference in rank between the two contestants.

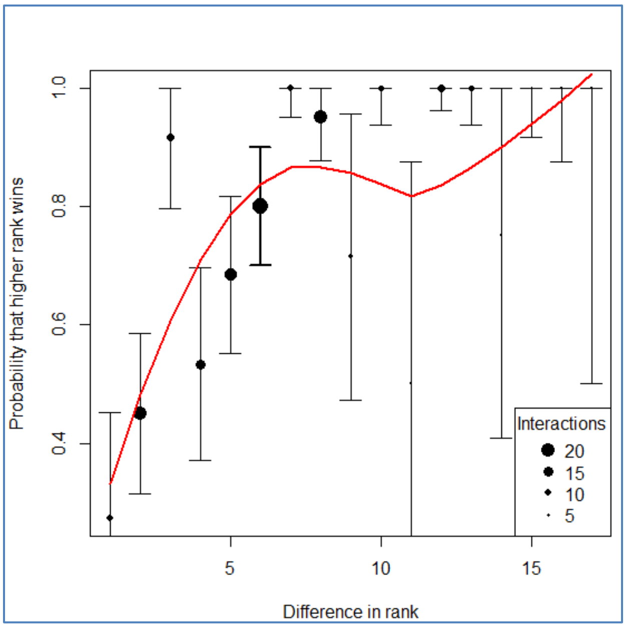

Figure S5. Inter_Lot1. It indicates the probability of winning of the higher-ranked individual based on the difference in rank between the two contestants.

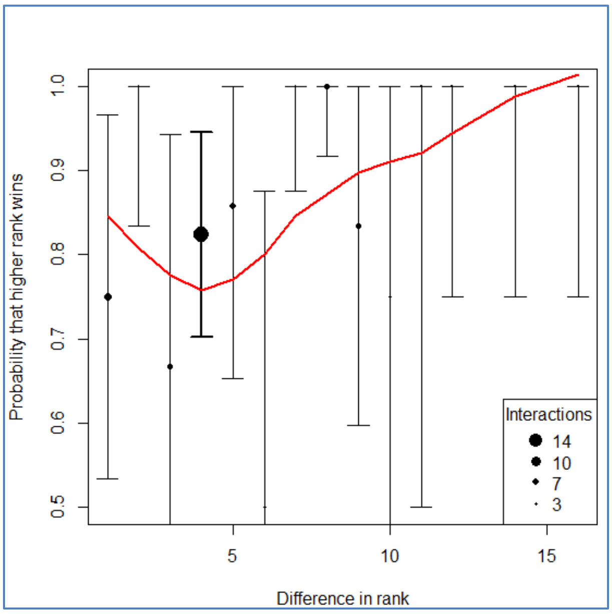

Figure S6. Inter_Lot2. It indicates the probability of winning of the higher-ranked individual based on the difference in rank between the two contestants.

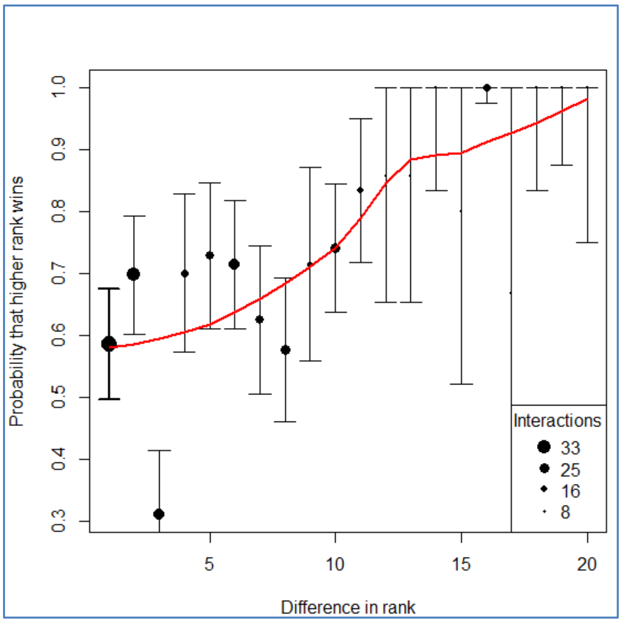

Figure S7. Inter_Lot3. It indicates the probability of winning of the higher-ranked individual based on the difference in rank between the two contestants.

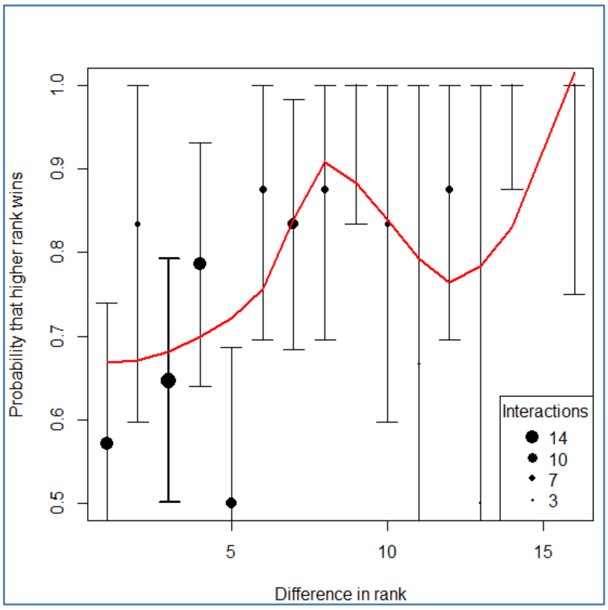

Figure S8. Inter_Lot3. It indicates the probability of winning of the higher-ranked individual based on the difference in rank between the two contestants.

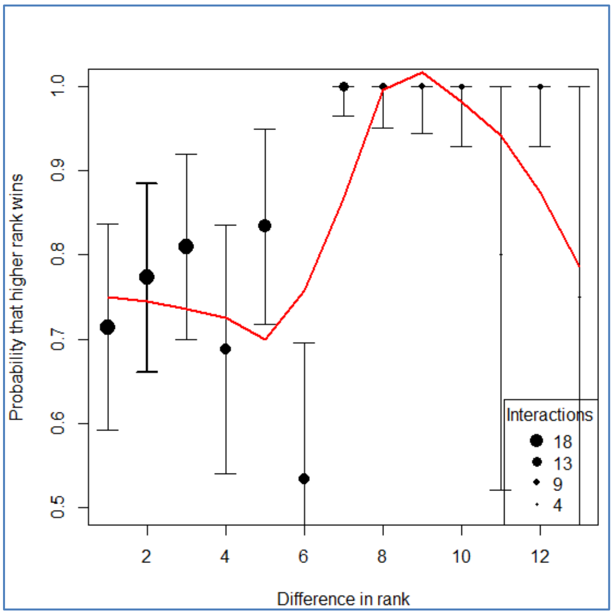

Figure S9. Subord_Lot1. It indicates the probability of winning of the higher-ranked individual based on the difference in rank between the two contestants.

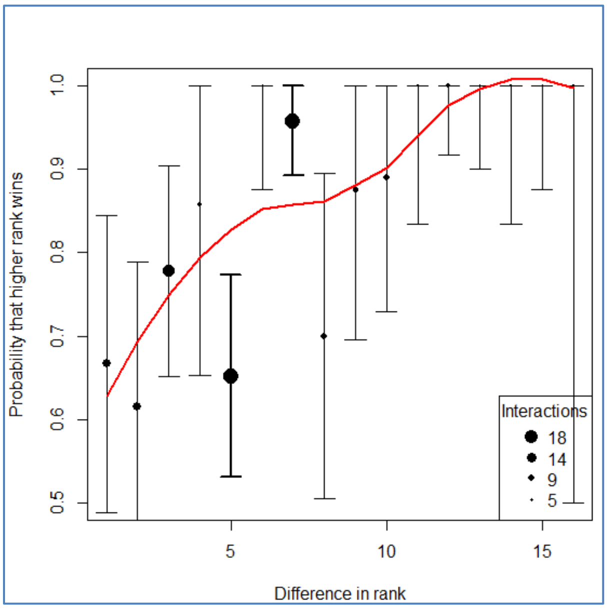

Figure S10. Subord_Lot2. It indicates the probability of winning of the higher-ranked individual based on the difference in rank between the two contestants.

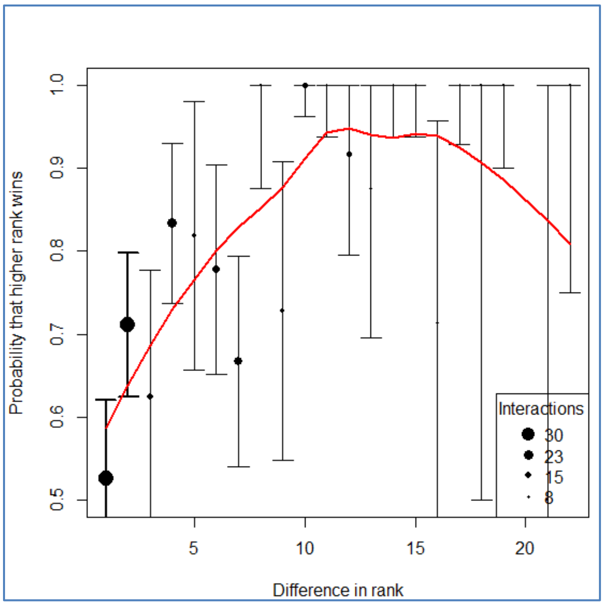

Figure S11. Subord_Lot3. It indicates the probability of winning of the higher-ranked individual based on the difference in rank between the two contestants.

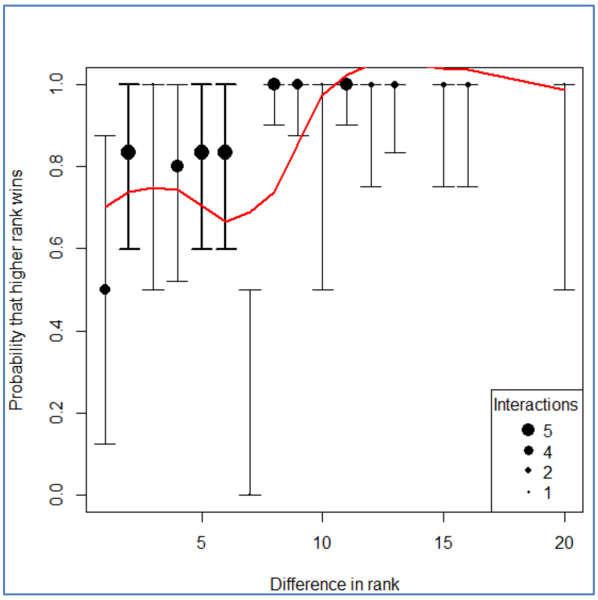

Figure S12. Subord_Lot4. It indicates the probability of winning of the higher-ranked individual based on the difference in rank between the two contestants.

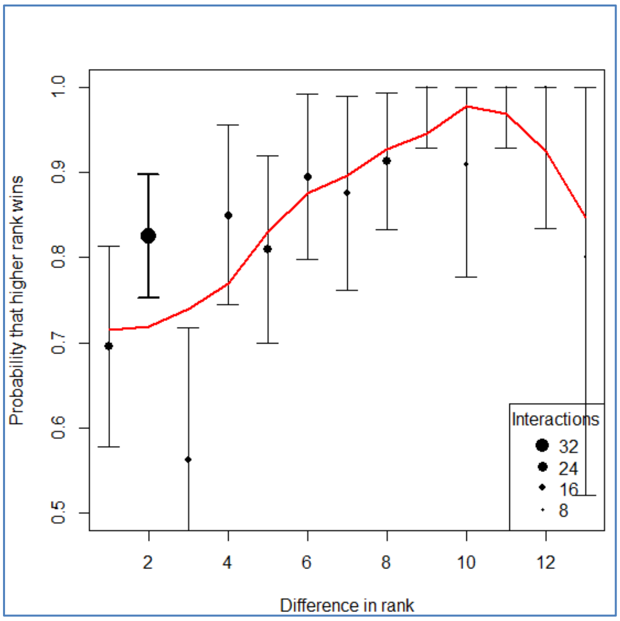

Figure S13. Final_Lote1. It indicates the probability of winning of the higher-ranked individual based on the difference in rank between the two contestants.

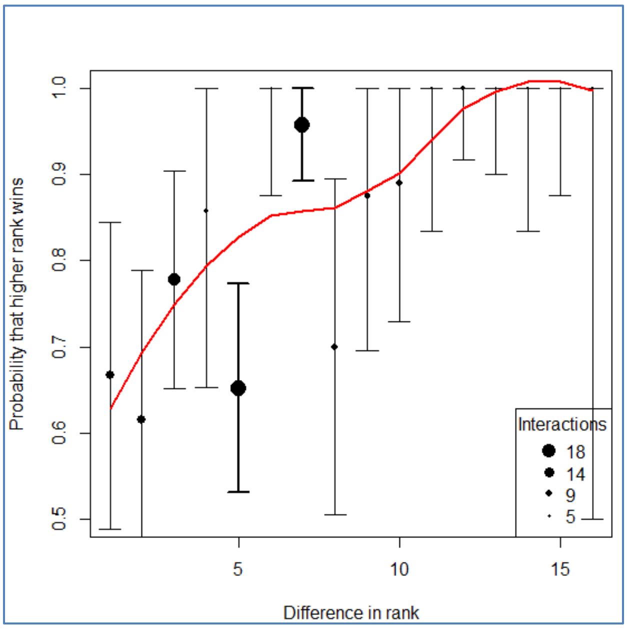

Figure S14. Final_Lote2. It indicates the probability of winning of the higher-ranked individual based on the difference in rank between the two contestants.

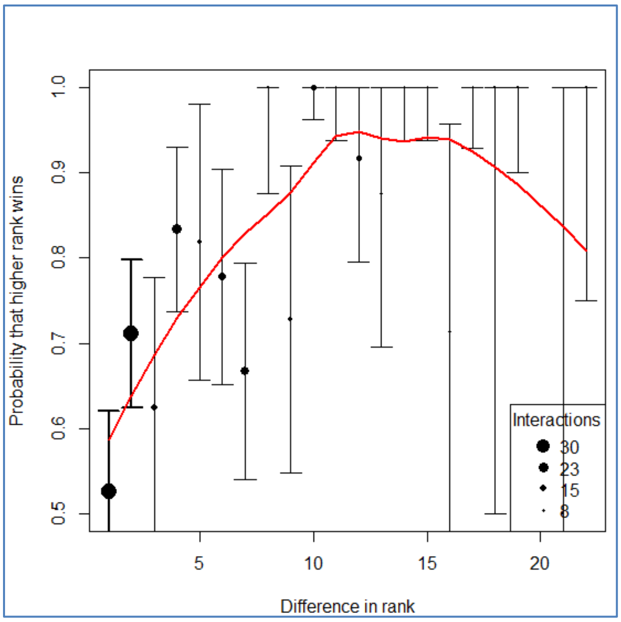

Figure S15. Final_Lote3. It indicates the probability of winning of the higher-ranked individual based on the difference in rank between the two contestants.

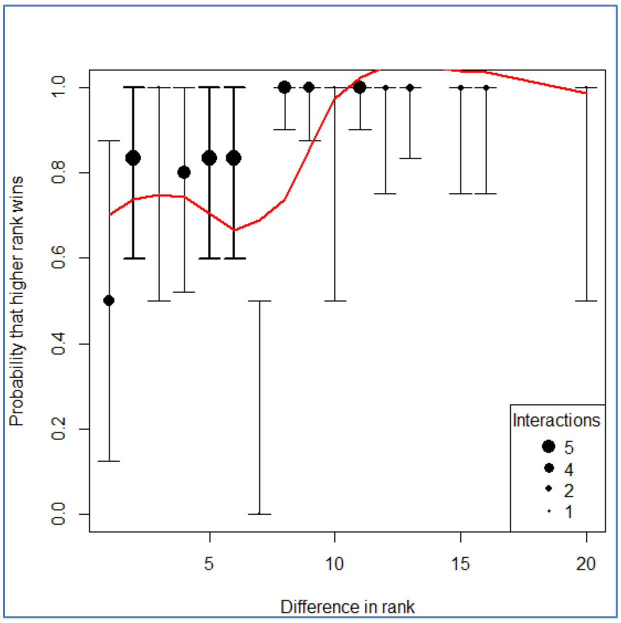

Figure S16. Final_Lote4. It indicates the probability of winning of the higher-ranked individual based on the difference in rank between the two contestants.

Table S2: Regrouping and dominance status of crossed heifers in feedlot

Lot 1

Regrouping 1				Regrouping 2				Regrouping 3				Regrouping 4			
Animal	Rank	Elo rating	Status	Animal	Rank	Elo rating	Status	Animal	Rank	Elo rating	Status	Animal	Rank	Elo rating	Status
73	1	26.448	D	79	1	16.859	D	11	1	13.893	D	11	1	14.085	D
6	2	20.7735	D	9	2	16.806	D	59	2	13.167	D	98	2	13.653	D
76	3	20.7735	D	75	3	16.634	D	9	3	12.099	D	65	3	12.011	D
9	4	20.72	D	64	4	16.197	D	73	4	10.798	D	73	4	10.805	D
64	5	19.734	D	73	5	15.06	D	48	5	10.596	D	48	5	10.58	D
25	6	19.331	D	48	6	14.712	D	45	6	9.22	I	45	6	9.513	I
85	7	18.797	D	76	7	14.435	D	7	7	8.551	I	7	7	8.199	I
86	8	17.907	I	7	8	13.859	I	31	8	8.281	I	75	8	7.807	I
7	9	17.283	I	85	9	12.268	I	0	9	8.173	I	31	9	7.718	I
0	10	16.958	I	66	10	11.285	I	75	10	7.8	I	0	10	7.698	I
4	11	14.528	I	0	11	10.955	I	4	11	4.401	S	74	11	4.93	S
27	12	13.478	I	91	12	9.43	I	74	12	4.386	S	4	12	3.901	S
31	13	10.808	I	28	13	8.007	I	56	13	3.477	S	2	13	3.582	S
91	14	10.608	I	27	14	6.975	I	2	14	2.999	S	56	14	3.21	S
66	15	10.223	I	59	15	5.794	S	87	15	2.74	S	87	15	2.308	S
87	16	9.863	S	2	16	5.169	S								
2	17	9.626	S	56	17	5.035	S								
38	18	8.5005	S	4	18	4.457	S								
32	19	6.289	S	31	19	4.156	S								
59	20	6.057	S	87	20	1.907	S								
28	21	2.97	S												

Lot 2

Regrouping 1				Regrouping 2				Regrouping 3				Regrouping 4			
Animal	Rank	Elo rating	Status	Animal	Rank	Elo rating	Status	Animal	Rank	Elo rating	Status	Animal	Rank	Elo rating	Status
84	1	19.806	D	72	1	18.884	D	57	1	22.973	D	39	1	18.102	D
61	2	16.194	D	6	2	18.31	D	39	2	18.104	D	6	2	16.182	D
67	3	15.604	D	61	3	15.63	D	6	3	16.362	D	91	3	15.36	D
33	4	14.948	D	99	4	15.348	D	99	4	15.937	D	85	4	15.282	D
99	5	14.541	D	39	5	14.977	D	91	5	15.171	D	38	5	14.166	D
70	6	13.887	D	007	6	13.868	D	85	6	15.057	D	59	6	13.167	D
007	7	13.868	D	49	7	13.155	I	38	7	14.243	I	9	7	12.099	I
95	8	12.195	I	70	8	13.154	I	33	8	11.275	I	33	8	11.394	I
70	9	8.756	I	57	9	12.616	I	86	9	11.117	I	86	9	11.268	I
95	10	8.419	I	58	10	11.949	I	40	10	9.991	I	40	10	9.638	I
57	11	8.104	I	84	11	9.999	I	61	11	9.142	I	61	11	9.068	I
51	12	7.726	I	38	12	9.801	I	70	12	8.756	I	70	12	8.702	I
82	13	7.363	I	95	13	9.088	I	95	13	8.419	I	95	13	8.434	I
82	14	6.54	I	86	14	7.916	S	51	14	7.726	S	51	14	7.601	S
94	15	6.079	I	67	15	6.118	S	82	15	6.54	S	82	15	6.621	S
6	16	5.108	S	13	16	5.566	S	67	16	4.538	S	67	16	4.533	S
67	17	4.538	S	33	17	5.277	S	58	17	4.226	S	58	17	4.222	S
58	18	4.226	S	82	18	3.801	S	28	18	2.938	S	28	18	3.148	S
28	19	2.938	S	40	19	3.329	S	32	19	1.017	S	32	19	1.013	S
40	20	2.684	S	32	20	1.214	S								
46	21	1.405	S												
32	22	1.017	S												

Lot 3

Regrouping 1				Regrouping 2				Regrouping 3				Regrouping 4			
Animal	Rank	Elo rating	Status	Animal	Rank	Elo rating	Status	Animal	Rank	Elo rating	Status	Animal	Rank	Elo rating	Status
80	1	28.123	D	12	1	21.309	D	84	1	22.638	D	57	1	22.973	D
63	2	25.996	D	3	2	20.623	D	3	2	21.631	D	84	2	22.643	D
49	3	24.484	D	78	3	18.693	D	80	3	21.137	D	3	3	21.696	D
3	4	24.041	D	36	4	18.086	D	81	4	20.283	D	80	4	21.205	D
93	5	23.93	D	80	5	18.044	D	93	5	17.817	D	93	5	18.028	D
79	6	22.1535	D	93	6	17.955	D	94	6	15.184	D	99	6	15.937	D
12	7	21.531	D	1	7	17.889	D	007	7	14.696	D	94	7	15.042	D
81	8	21.251	D	60	8	16.403	D	49	8	14.05	D	007	8	14.573	D
34	9	20.7995	I	35	9	16.382	I	63	9	13.849	I	63	9	14.228	I
35	10	19.347	I	46	10	15.976	I	36	10	13.756	I	49	10	13.726	I
55	11	18.783	I	55	11	15.476	I	12	11	13.597	I	12	11	13.605	I
60	12	18.325	I	94	12	15.23	I	1	12	13.307	I	36	12	13.585	I
1	13	17.352	I	81	13	12.341	I	37	13	11.381	I	1	13	13.245	I
36	14	14.808	I	34	14	11.842	I	14	14	11.195	I	37	14	11.54	I
56	15	14.127	I	63	15	10.85	I	46	15	10.678	I	14	15	11.175	I

30	16	13.918	I	47	16	10.831	I	69	16	10.279	I	**46**	**16**	**10.58**	**I**
78	17	12.504	I	37	17	10.764	S	78	17	10.01	S	69	17	10.415	S
37	18	12.381	I	14	18	10.463	S	47	18	5.757	S	78	18	9.476	S
14	19	12.34	S	26	19	8.383	S	30	19	5.441	S	47	19	6.202	S
26	20	12.232	S	30	20	7.442	S	26	20	4.903	S	30	20	5.612	S
43	21	10.329	S	43	21	4.949	S	43	21	3.917	S	26	21	4.809	S
89	22	8.67	S	69	22	4.433	S	89	22	3.636	S	43	22	3.828	S
69	23	8.0795	S	90	23	3.795	S	90	23	2.388	S	89	23	3.585	S
47	24	5.726	S	89	24	1.634	S	**34**	**24**	**1.547**	**S**	90	24	2.292	S
90	25	3.429	S												
42	**26**	**3.192**	**S**												
77	**27**	**1.034**	**S**												

Lot 4

Regrouping 1				Regrouping 2				Regrouping 3				Regrouping 4			
Animal	Rank	Elo rating	Status	Animal	Rank	Elo rating	Status	Animal	Rank	Elo rating	Status	Animal	Rank	Elo rating	Status
53	1	23.354	D	10	1	21.861	D	**60**	**1**	**21.941**	**D**	**60**	**1**	**21.935**	**D**
98	**2**	**22.698**	**D**	**98**	**2**	**21.839**	**D**	50	2	18.598	D	**81**	**2**	**20.316**	**D**
29	3	20.239	D	15	3	21.366	D	10	3	18.216	D	50	3	18.665	D
68	4	20.222	D	68	4	19.193	D	71	4	17.221	D	10	4	18.417	D
83	5	19.028	D	29	5	15.154	D	72	5	16.274	D	71	5	17.3235	D
96	6	17.089	D	52	6	14.576	D	15	6	14.347	D	72	6	16.277	D
58	7	16.7025	D	97	7	14.551	D	97	7	14.285	D	15	7	14.3175	D
62	8	16.036	D	**77**	**8**	**14.503**	**I**	**98**	**8**	**13.653**	**I**	97	8	14.119	I
72	9	15.087	I	83	9	13.614	I	96	9	13.201	I	96	9	13.37	I
15	10	15.083	I	8	10	12.413	I	29	10	12.155	I	88	10	12.059	I
10	11	15.0395	I	**65**	**11**	**12.407**	**I**	**65**	**11**	**12.011**	**I**	29	11	11.816	I
97	12	13.442	I	5	12	10.914	I	88	12	11.844	I	68	12	11.299	I
8	13	12.083	I	62	13	10.732	I	8	13	11.589	I	8	13	11.198	I
50	14	9.668	I	**42**	**14**	**10.501**	**I**	68	14	11.34	I	92	14	9.6315	I
11	**15**	**9.383**	**I**	71	16	8.534	S	92	15	9.6505	S	53	15	8.296	S
88	16	8.327	S	**11**	**17**	**8.126**	**S**	52	16	8.2525	S	52	16	7.9705	S
59	17	8.258	S	53	18	7.681	S	53	17	8.246	S	62	17	6.395	S
45	**18**	**7.629**	**S**	50	19	5.575	S	62	18	6.247	S	**77**	**18**	**5.303**	**S**
71	19	7.566	S	**45**	**20**	**4.517**	**S**	**77**	**19**	**5.166**	**S**	**42**	**19**	**5.175**	**S**
52	20	5.157	S	92	21	3.792	S	**42**	**20**	**5.008**	**S**	**35**	**20**	**4.682**	**S**
65	**21**	**3.951**	**S**	88	22	3.212	S	**35**	**21**	**4.595**	**S**	5	21	2.969	S
75	**22**	**3.176**	**S**					5	22	2.994	S	**34**	**22**	**1.466**	**S**
48	**24**	**1.41**	**S**												

D, dominant; I, intermediate; S, subordinate.

4. CHAPTER 3 - Changes in social structure in feedlot heifers standardized by weight

Manuscript submitted to Applied Animal Behavior Science

Abstract: This study aimed to examine changes in the social structure of heifers resulting from regrouping for lot standardization by weight and assess the effects on animal temperament, performance, and occurrence of disputes during confinement. For this, 83 ten-month-old Angus × Nellore heifers were confined to 4 pens, each with an available area of 800 m^2, 130 m^2 of shaded space, 16 linear meters of concrete troughs, and shared drinkers. Feed with increasing levels of concentrate was provided twice a day, and water was available *ad libitum.* From the second weighing onward, heifers were subjected to three regroupings within a 1-month period (days 28, 56, and 84 of confinement). The top 25% heaviest heifers were allocated to lot 1 (n = 20), animals in the top 26–50% of weight were allocated to lot 2 (n = 21), the next 25% were placed in lot 3 (n = 21), and animals in the bottom 25% were allocated to lot 4 (n = 21) at each weighing. Reactivity during weighing and exit velocity were measured before the first and after the third regrouping. Agonistic behavior was analyzed on three consecutive days following each regrouping and used to classify animals into social classes (dominant, intermediate, and subordinate) by lot and Elo rating. Steepness was used to assess the uncertainty of the hierarchy. The steepness values ranged from 0.55 to 0.91. Heifers demonstrated a very flat and non-transitive hierarchy. Animal performance was measured in terms of mean daily weight gain during the experimental period. Correlations between reactivity, daily activities, social behavior, and animal performance were assessed. Elo score showed negative correlation with interactions in both regroupings (r_{first} = - 0.70, $P < 0.05$ and r_{third} = - 0.77, $P < 0.05$). In both regroupings, there was a significant positive correlation between Elo ratings and degree centrality (r_{first} = 053, $P < 0.05$ and r_{third} = 0.79, $P < 0.05$), indicating that dominant animals also play a central role in agonistic interaction networks. There was a significant increase in final reactivity ($P = 0.01$), as well as in final exit velocity, both of which were influenced by regrouping ($P = 0.01$). Number of fights differed between regroupings ($P = 0.01$), with the highest number of occurrences observed after regrouping 1 (1.51 ± 0.14). Likewise, number of fights differed between days ($P < 0.01$), decreasing with each day post-regrouping. Mean daily weight gain was highest before regrouping ($P < 0.01$). Regrouping promoted negative changes in the temperament, performance, and social structure of feedlot heifers. However, agonistic interactions decreased over time.

Keywords: agonistic behavior, dominant, fights, lot regrouping.

4.1. INTRODUCTION

A common practice in Brazilian livestock systems, confinement of beef cattle has been widely adopted since the 1960s (GIRO do BOI, 2019) and continues to expand, with growth projections for the domestic and foreign markets in the coming years (SENAR, 2018; ABIEC, 2021). Small-scale farmers who do not have access to technological methods for cattle finishing may opt to outsource the fattening process (MINERVA FOODS, 2021), a practice that gained momentum in 2021, accounting for 25% of animals finished in feedlots (BOD, 2021).

Finishing cattle in feedlot systems enhances meat quality in periods of pasture scarcity, optimizes yield per area (MONTELLI et al., 2019), and improves animal performance and health indicators. Such benefits stem from gains in nutritional efficiency, sanitary control, and fattening rate, which makes it possible to obtain two or more cycles per year. The end results are a reduction in slaughter age, an increase in entry–exit events, and greater capital turnover. Of note, it is increasingly common to finish young crossbreed animals in feedlots (LANNA; ALMEIDA, 2005; MACHADO et al., 2019), differing from extensive farming, which still accounts for 80% of finished animals, producing older, pasture-raised animals (SOUZA, 2011). However, despite the benefits of feedlots, research shows that consumers are increasingly demanding animal traceability and have growing concerns about the welfare of animals raised in confined systems (HÖTZEL et al., 2018).

There are challenges in the adaptation of animals to the feedlot environment, particularly when factors such as high population density in pens are involved (MACITELLI, 2015). Behavioral issues include sodomy (LOPES, 2017), which can affect 2% of individuals in large lots (BLACKSHAW et al., 1997), and increased likelihood of carcass bruises (MOUNIER et al., 2006).

Sorting cattle into homogeneous groups at the beginning of confinement makes it easier to understand the needs of each lot, in addition to reducing environmental and managerial challenges (MOUNIER et al., 2005). This is especially important during the adaptation period, which has a higher biological cost for animals, associated with constant changes in the social status of individuals (BROOM, 1986; FRASER et al., 2013). Lots can be segregated based on sex, genetic group, and age, among other characteristics. Homogeneous lots tend to decrease competition between individuals, which facilitates identification of problems related to the production system (MACHADO et al., 2019).

Lot regrouping or mixing is common during the confinement period (MAKAGON et al., 2012), as well as before transport to slaughter. This practice significantly increases the frequency of agonistic interactions, causing psychological stress, physical exhaustion, and physiological changes that impact animal welfare (COSTA, 2013). This study aimed to measure the effects of regrouping in feedlot heifers standardized by weight on the prevalence of agonistic interactions, animal performance, and reactivity throughout the finishing phase.

4.2. MATERIAL AND METHODS

All protocols used in the experiment were approved by the local animal ethics committee (CEUA/FZEA/USP protocol No. 8806140515).

4.2.1. Facilities and handling

The experiment was carried out between August 2020 and January 2021 at the Biometeorology and Ethology Laboratory, Faculty of Animal Science and Food Engineering, University of São Paulo, Brazil. The vivarium has a feedlot area comprising 10 pens, each with 800 m^2 of available area and 130 m^2 of shaded space (80% blockage of solar radiation). Pens are also equipped with 16 linear meters of concrete troughs. Circular drinkers are shared between two pens. Animals were handled using flags and at the coolest hours of the day, according to rational procedures.

4.2.2. Diet

Initially, heifers had 15 days of diet adaptation, during which they were provided with feed containing increasing proportions of concentrate. Feed was provided simultaneously to all lots, twice a day (6 a.m. and 3 p.m.), and water was available *ad libitum*. The amount of feed provided daily was adjusted based on the trough scores proposed by Lanna and Almeida (2005), as follows: 0, empty trough; 1, trough containing a bit of leftover feed at the bottom (<25% of the amount provided in the previous feeding); 2, leftovers reach up to 25% of the amount provided in the previous feeding; 3, up to 50% of leftovers; 4, up to 75% of leftovers; and 5, 100% of leftovers. Concentrate levels varied according to dietary requirements, as follows: days 1 to 15 of confinement, 30% concentrate; days 16 to 45, 40% concentrate; days 46 to 75, 50% concentrate; and day 76 to slaughter, 70% concentrate. This protocol allowed us to meet the nutritional requirements of heifers and achieve weight gains greater than 1500 g animal^{-1} day^{-1}.

4.2.3. Animals and groupings

Eighty-three F1 Angus × Nellore heifers, aged 10 months, from the same farm and habituated to each other on pasture, were used in the experiment. Initially, heifers were randomly grouped into four feedlots. The mean initial liveweight was 280 kg. After the second weighing (day 28 of confinement), when heifers had a mean weight of 353 ± 2.4 kg, the following regrouping scheme was applied: the top 25% heaviest animals were allocated to lot 1 (*n* = 20), the bottom 25% heaviest animals were allocated to lot 4 (*n* = 21), animals whose weight was above the average but below the minimum weight of lot 1 were placed in lot 2 (*n* = 21), and animals whose weight was below the average but above the maximum weight of lot 4 were placed in lot 3 (*n* = 21).

The same regrouping protocol was applied after the next weighing (day 56, mean live weight of 401 ± 2.4 kg; day 84, mean live weight of 445 ± 2.4 kg) (Fig. 1). In each regrouping, animals were allocated according to their individual weights but never returned to their initial (contemporary) lot.

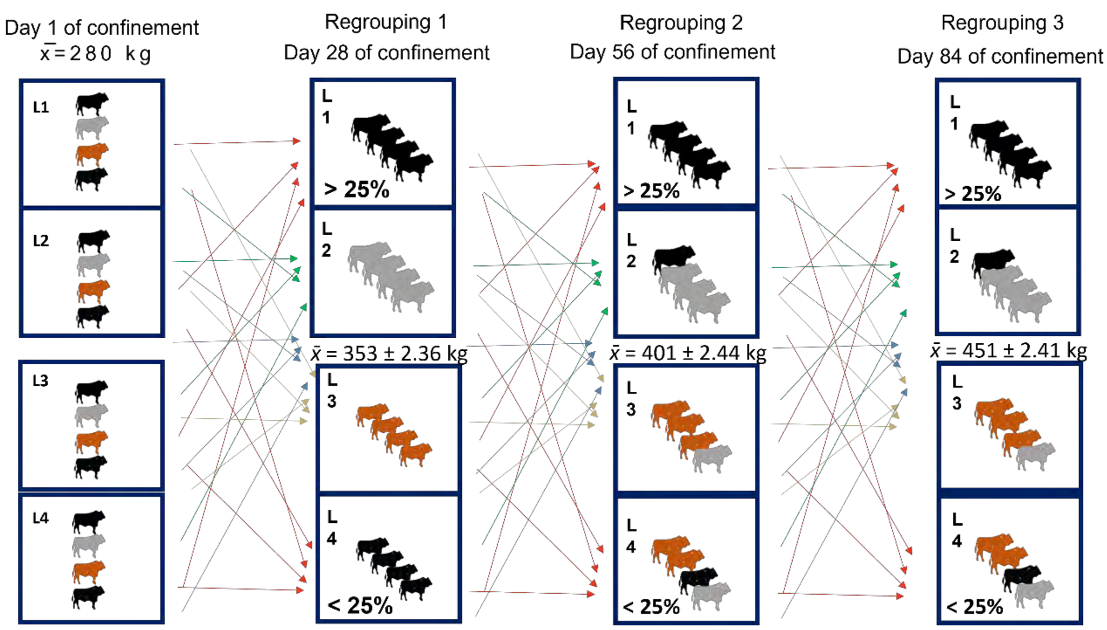

Figure 1. Animal allocation scheme in regroupings 1 (day 28), 2 (day 56), and 3 (day 84). Source: the authors.

4.2.4. Daily activity and behavioral observations

A timeline of experimental procedures is shown in Fig. 2. Reactivity was assessed during weighing on the first day of confinement and at the final weighing (one month after the last regrouping), using the reactivity scoring system described by Fordyce, Goddard, and Seifert (1982) and adapted by Titto (2016). Reactivity is measured in the first 4 s after the animal enters the scale as a function of displacement and tension characteristics. A score of 1 is assigned to animals that show little to no agitation, and a score of 4 is assigned to highly agitated animals with trembling limbs and body (Table 1).

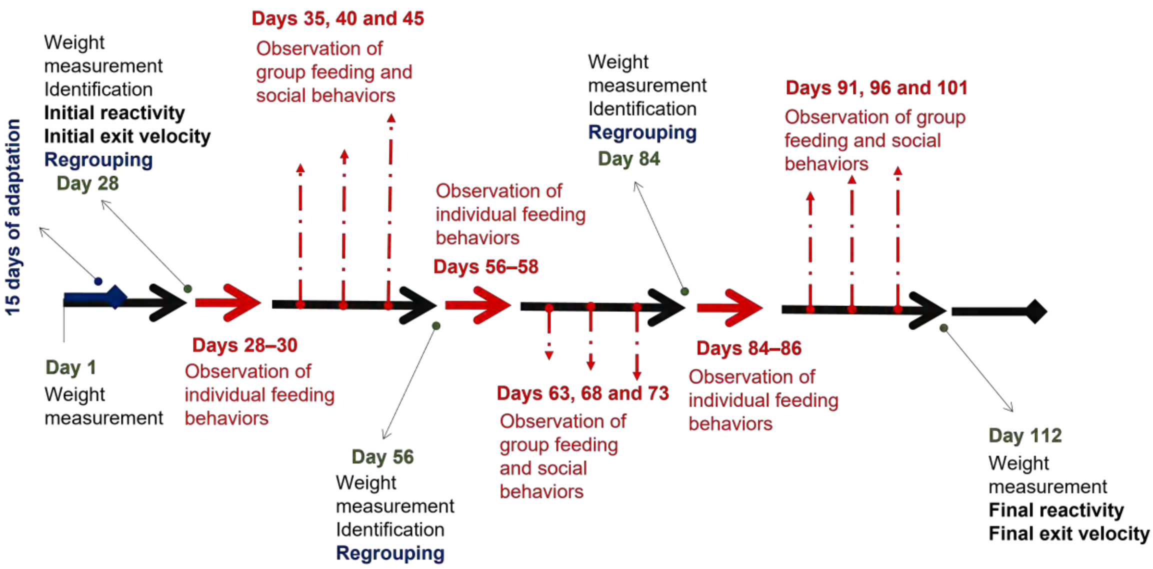

Figure 2. Timeline of behavioral observations and performance analysis of feedlot heifers. Source: the authors.

Table 1. Reactivity scoring system used to assess feedlot heifers before the first regrouping (day 28) and a month after the final regrouping (day 112).

Score/reactivity	Description
(1) Not reactive	Animal is relaxed. No sudden movements.
(2) Slightly reactive	Animal is slightly agitated or alert.
(3) Reactive	Animal moves vigorously, is alert, attempts to escape.
(4) Very reactive	Animal is very tense, panting, jumping, and thrashing about. May exhibit visible sclera and muscle twitching.

Source: adapted from Fordyce, Goddard, and Seiffert (1982) and Titto (2016).

Exit velocity (m s^{-1}) (BURROW et al., 1988) was evaluated on the same days as reactivity (on the first day of confinement and at the final weighing). Exit velocity was estimated by measuring the time the animal took to cross a 2 m corridor after leaving the weighing scale, as described by Braga (2016). Results were calculated by dividing the time recorded (in seconds) by the corridor length (2 m).

For analysis of social behavior, agonistic interactions were measured (Table 2) by continuous focal sampling. Authors and recipients of interactions were monitored for three consecutive days after each regrouping from 7 a.m. to 1 p.m. and from 2 p.m. to 6 p.m. Daily activities were also recorded (Table 3).

The prevalence of daily activities was assessed by observing the animals on three series of 3 consecutive days spaced at 5-day intervals after the first (days 35, 40, and 45), second (days 63, 68, and 73), and third (days 91, 96, and 101) regroupings. Daily activities were recorded by scan sampling from 7 a.m. to 1 p.m. and from 2 p.m. to 6 p.m. (FRANCIS, 1987). Observations of agonistic behaviors and daily activities were conducted by different trained observers.

Table 2. Descriptors used to assess social dominance behaviors in feedlot heifers.

Behavior	**Descriptor**
Headbutt without displacement	Animal uses its head to hit another animal from the group in any part of the body. The receiver, however, does not move or give up its position.
Headbutt with displacement	Animal uses its head to hit another animal from the group in any part of the body, forcing the receiver to move or give up its position.
Fighting	Animals push their heads against each other, exerting force through their front feet. Aggression is perpetrated by both animals but results in the displacement of the receptor and causes it to abandon the fight.
Competition for feed troughs or drinkers	An animal standing near a resource (barrier and/or trough) is displaced by another animal. The receiver moves closer, threatens, and/or vocalizes.

Source: adapted from Moran and Doyle (2015).

Table 3. Description of feeding behaviors and activities recorded during daily observations.

Activity	**Description**
Eating	Ingesting feed with the mouth in the barrier
Ruminating	Chewing movements not accompanied by ingestion, either standing or lying down
Idle	No apparent activity, either standing or lying down
Drinking water	Drinking water from trough
Other activities	Affiliative social activities with other members of the group or exploration of the feeding area

Source: adapted from Moran and Doyle (2015).

4.2.5. Social status

The Elo rating system, a method originally developed by Elo (1978) to calculate the probability of chess players winning or losing a game, was used to calculate the dominance hierarchies of heifers. The method is based on an interaction sequence, rather than on an interaction matrix, with ratings being continuously updated according to sequential observations of interactions (NEUMANN et al., 2011). Ratings are updated according to whether the higher- or lower-rated individual wins or loses the interaction, as shown by Eqs. (1–4).

If the higher-rated individual wins:

$$\mathbf{WinnerRating_{new}} = \mathbf{WinnerRating_{old}} + (\mathbf{1} - \boldsymbol{p}) \times \mathbf{k} \quad \mathbf{(1)}$$

$$\mathbf{LoserRating_{new}} = \mathbf{LoserRating_{old}} - (\mathbf{1} - \boldsymbol{p}) \times \mathbf{k} \quad \mathbf{(2)}$$

If the lower-rated individual wins:

$$\mathbf{WinnerRating_{new}} = \mathbf{WinnerRating_{old}} + (\boldsymbol{p} \times \mathbf{k}) \quad \mathbf{(3)}$$

$$\mathbf{LoserRating_{new}} = \mathbf{LoserRating_{old}} - (\boldsymbol{p} \times \mathbf{k}) \quad \mathbf{(4)}$$

where p is the expectation of winning for the higher-rated individual, which is a function of the absolute difference in rating between the two interaction partners before the interaction (ALBERS; DE VRIES, 2001) and k is a constant determining the amount of rating points that an individual gains or losses after an encounter. The value of k is usually set between 16 and 200 and, once chosen, remains unchanged throughout the rating process (NEUMANN et al., 2011).

Because the Elo rating estimates competitive abilities by continuously updating an individual's success rate, it reflects a cardinal measure of success. Thus, differences between ratings are on an interval scale and may require the application of parametric statistics in further analyses (NEUMANN et al., 2011). As suggested by Sanchez-Tojar et al. (2018) as a source of hierarchical uncertainty, the steepness of dominance hierarchies was estimated based on the random repeatability of Elo ratings. First, interaction matrices were converted into a random sequence of possible interactions. Interaction matrices were generated using 1000 random interaction sequences. The Elo rating was then applied to each sequence, resulting in a total of 1000 scores for each individual, which were used to estimate Elo rating repeatability.

Dominance hierarchy steepness can range from very steep, where higher-rated individuals win all conflicts with a probability close to 1, to very flat, where dyadic outcomes are highly unpredictable and the probability of the higher-rated individual winning a conflict is only slightly greater than 0.5 (SANCHEZ-TOJAR et al., 2018). Finally, triangle transitivity was calculated using the stable ordering measure proposed by McDonald and Shizuka (2012).

The applicability of the Elo rating system is not limited to the analysis of decided dominance interactions. It can also incorporate undecided interactions and allows for a detailed assessment of hierarchies by weighting interactions according to their properties and the magnitude of the author or recipient. This procedure provides a more accurate assessment of dominance relationships. The social status attributed to each animal depends on the number of animals in each lot, categorized as dominant, intermediate, and subordinate (Eq. 5):

$$\frac{\textbf{Number of animals in the lot}}{\textbf{3}} = \textbf{Number of animals in each level} \tag{5}$$

4.2.6. Animal performance

Animal performance was measured in terms of mean daily gain, calculated by dividing the weight gain by the number of days between weighing (kg.day^{-1}). The animals were weighed on the first day of confinement upon arrival at the feedlot and then every 28 days for the next 105 days of confinement, plus 15 days of diet adaptation. The final weight was used to evaluate the total gain and estimate the impact of regrouping on slaughter weight.

4.2.7. Statistical analysis

Modeling of social status

Binary behavior data were modeled using maximum likelihood estimates for binomial generalized linear mixed models with a logit link function using the R package glmTMB (BROOKS et al., 2017). Models included independent variables as fixed effects and animals as random effects. Model parameters were generated using the R package car (FOX and WEISBERG, 2019). Pairwise post hoc comparisons using *p*-values adjusted by Tukey's test were performed to compare classes of independent variables using the R package multcomp (HOTHORN et al., 2008). Differences were considered significant at $p < 0.05$. Using the "ggstatsplot" R package (Patil, 2021), a partial correlation matrix was constructed to evaluate the relationship between the variables. Analyses were performed using R version 4.1.2 (R Core Team, 2021).

Performance and temperament variables

Analyses were performed to investigate the effects of Elo rating on regrouping, performance, and social and feeding behaviors using SAS PROC MIXED (SAS Institute Inc., Cary, NC, USA). The REPEATED command was applied to model the residual covariance structure within each lot. Relationships between groupings, performance, temperament, and social and feeding behaviors were assessed by estimates of residual correlations, obtained via multivariate analyses, using SAS PROC GLM (SAS Institute Inc., Cary, NC, USA). Models included the fixed effects of weight at regrouping, reactivity, exit velocity, social and feeding behavior, hierarchy, and trough scores before and after each regrouping, as well as the interaction between factors in each regrouping. Interaction effects were excluded from the model when non-significant at the 5% level. Models included random effects of animals (within each regrouping), residual effects, and specific fixed effects for each characteristic and temperament, feeding, and social behaviors. These factors were included as a class for weight and as a covariate for exit velocity, reactivity, and regrouping.

4.3. RESULTS

Regroupings were performed according to live weight; thus, the number of regrouped heifers differed according to lot. Lots 1 and 4 had the largest number of individuals who were not regrouped and remained in their original lot throughout the experimental period, serving as extremes of the total group (Table 4).

Table 4. Percentage of reallocated and non-reallocated (contemporary) individuals throughout the experimental period according to lot of origin.

Lot	Reallocated individuals	Contemporaries
1	55%	45%
2	71%	29%
3	67%	33%
4	45%	55%

4.3.1. Animal temperament

There were significant differences in reactivity at the beginning and end of the experiment ($P < 0.01$) and interaction lot x time (P<0.02). Initial reactivity scores were lower than values at the end of regroupings and different to lot 2 and 4 (Table 5). Exit speed was lower before regroupings, that is, animals took longer to travel the pathway (0.92 $m.s^{-1}$; 1.16 $m.s^{-1}$; $P < 0.01$) and interaction lot x time was significant (P<0.002). In post-regrouping evaluations, animals had a higher exit speed (Table 5).

Table 5. Reactivity score and exit speed of feedlot Angus × Nellore heifers after 28 (initial) and 112 (final) days of confinement.

	Initial	Final	P value initial x Final
Reactivity score			
Lot 1	**1.73**±0.23	**1.81**±0.19	**0.561**
Lot 2	**1.26**±0.22	**2.35**±0.21	**0.017**
Lot 3	**1.79**±0.24	**1.95**±0.20	**0.990**
Lot 4	**1.59**±0.21	**2.65**±0.19	**0.009**
Exit speed ($m.s^{-1}$)			
Lot 1	**1.48**±0.12	**0.86**±0.10	**0.629**
Lot 2	**1.02**±0.12	**1.27**±0.12	**0.793**
Lot 3	**0.71**±0.13	**1.29**±0.11	**0.015**
Lot 4	**0.85**±0.11	**1.22**±0.10	**0.243**

Values are presented as mean ± standard error. Means within a column followed by different lowercase letters differ significantly at the 5% significance level.

4.3.2. Regrouping and aggressiveness

There was an effect of regrouping and lot on agonistic interactions ($P < 0.05$). In the first regrouping, the lowest agonistic interactions were recorded in lots 1 and 2, the lots with the heaviest animals ($P < 0.05$). In comparing differences between lots in the first regrouping, we found that heavier lots had about 50% fewer interactions than lower-weight lots (3 and 4). After regrouping 2, lot 3 had the highest frequency of agonistic interactions. At the end of regroupings, lots 1 and 2 had the lowest means of agonistic interactions (Fig. 3).

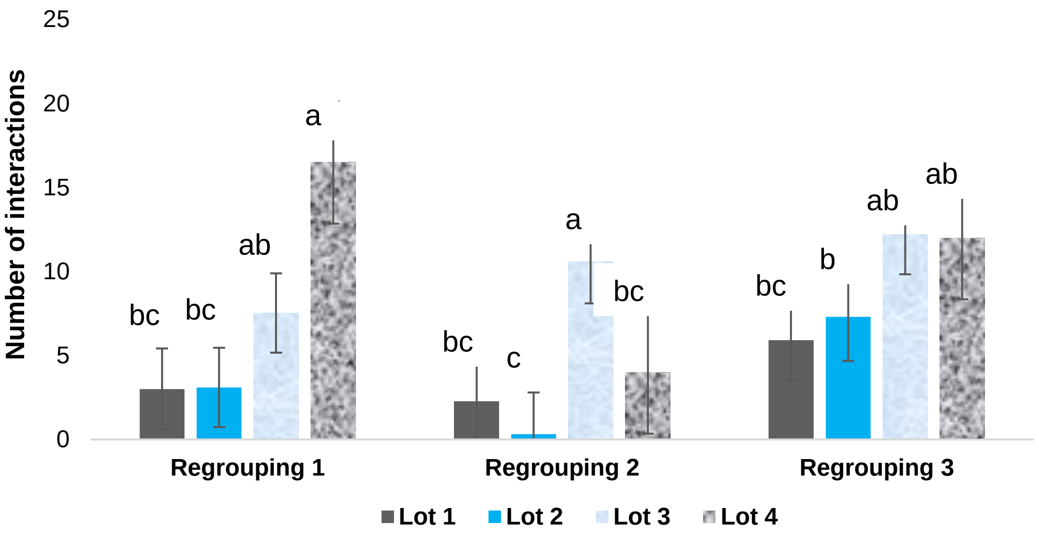

Figure 3. Agonistic interactions (mounting, fighting, headbutting with and without displacement, and trough disputes) of feedlot heifers subjected to successive regroupings according to lot at different periods after regrouping. Results are presented as mean ± standard error. Different letters indicate significant differences.

For analysis of hierarchical dominance, we assessed the behavior of animals in the three days following each regrouping, identifying which animals were the authors or recipients of agonistic interactions. There was an effect of regrouping ($P < 0.01$) and time after regrouping ($P < 0.01$) on number of fights. Regrouping and days after lot change exerted significant interaction effects on total number of interactions ($P < 0.01$) (Fig. 4), number of headbutts with displacement ($P < 0.01$), number of trough and drinker disputes ($P < 0.04$), and number of mounts ($P < 0.01$). On the other hand, number of headbutts without displacement was significantly influenced by regrouping only ($P < 0.02$). The lowest means of agonistic interactions were observed after regroupings 2 and 3 ($P < 0.05$). The first and third regroupings accounted for 80.5% of the total number of agonistic interactions (Tables 6 and 7). Steepness was used to assess the uncertainty of the hierarchy. The steepness values ranged from 0.55 to 0.91 (Table 8). In the first regrouping, Lot 3 yielded the highest value of 0.91, suggesting that the hierarchy of this group of heifers is quite steep and that estimations of hierarchy are highly certain. Heifers from other lots had a very flat hierarchy. The proportion of transitive relations was highest for Lot 3 in the first regrouping (Pt =1.00) and the lowest for Lot 1 in the first regrouping (Pt=0.00), Triangle transitivity was also highest for Lot 3 in the first regrouping however not significant (ttri = 1.00, p-value = 0.504). In both regroupings in Lot 2, the triangle transitivity was negative, indicating that relations between the heifers in these groups were more cycles than transitive.

Table 6. Frequency of agonistic interactions of feedlot Angus × Nellore heifers at different periods after each regrouping.

Period	**Agonistic interactions**					
	Headbutting with displacement	**Headbutting without displacement**	**Mounting**	**Trough disputes**	**Fighting**	**Total**
Regrouping 1	2.8 ± 0.18a	0.8 ± 0.08a	1.5 ± 0.17a	1.7 ± 0.19a	1.5 ± 0.14a	8.6 ± 0.43a
Regrouping 2	2.1 ± 0.19b	0.5 ± 0.09b	1.0 ± 0.18a	0.6 ± 0.20b	0.7 ± 0.14b	5.2 ± 0.45b
Regrouping 3	1.6 ± 0.19b	0.6 ± 0.09ab	1.1 ± 0.18a	0.2 ± 0.21b	0.3 ± 0.15b	4.0 ± 0.46b
Day 1	2.8 ± 0.26a	0.5 ± 0.12a	1.4 ± 0.25a	1.7 ± 0.28a	1.3 ± 0.20a	7.8 ± 0.62a
Day 2	2.7 ± 0.26ab	0.6 ± 0.12a	1.3 ± 0.25a	1.2 ± 0.2abc	1.4 ± 0.20a	7.4 ± 0.62a
Day 3	2.7 ± 0.26ab	0.7 ± 0.12a	1.1 ± 0.25a	1.6 ± 0.28ab	1.4 ± 0.20a	7.7 ± 0.62a
Day 8	1.7 ± 0.26bc	0.8 ± 0.12a	0.9 ± 0.25a	0.5 ± 0.28bcd	0.6 ± 0.20ab	4.6 ± 0.62b
Day 13	1.8 ± 0.28abc	0.5 ± 0.13a	1.1 ± 0.27a	0.06 ± 0.30c	0.06 ± 0.22b	3.6 ± 0.67b
Day 18	1.3 ± 0.26c	0.9 ± 0.12a	1.4 ± 0.25a	0.2 ± 0.28cd	0.1 ± 0.20b	4.0 ± 0.62b

Values are expressed as mean ± standard error. Means within a column followed by different lowercase letters differ significantly at the 5% significance level between regroupings and days. The frequency of interactions was evaluated on days 28 (Regrouping 1), 56 (Regrouping 2), and 84 (Regrouping 3) of confinement. Day 1 represents the mean of the first day after each regrouping (days 28, 56, and 84 of confinement); Day 2 represents the mean of the second day after each regrouping (days 29, 57, and 85 of confinement); Day 3 represents the mean of the third day after regrouping (days 30, 58, and 86 of confinement); Day 8 represents the mean of the eighth day after regrouping (days 35, 63, and 91 of confinement); Day 13, represents the mean of the thirteenth day after regrouping (days 40, 68, and 96 of confinement); and Day 18, represents the mean of the thirteenth day after regrouping (days 45, 73, and 101 of confinement). Interactions were evaluated by focal sampling on days 1, 2, and 3 and by scan sampling on days 8, 13, and 18.

Table 7. Frequency of agonistic interactions at different periods after each regrouping.

Period	Agonistic interactions						
	Regrouping Day	**Headbutting with displacement**	**Headbutting without displacement**	**Mounting**	**Trough disputes**	**Fighting**	**Total**
1	1	4.2 ± 0.44a	0.7 ± 0.20	3 ± 0.42a	3.4 ± 0.47a	2.1 ± 0.34ab	13.6 ± 1.04a
	2	4 ± 0.44ab	0.7 ± 0.20	2.1 ± 0.42ab	2.3 ± 0.47ab	2.3 ± 0.34ab	11.5 ± 1.04ab
	3	3.8 ± 0.44ab	0.7 ± 0.20	1.6 ± 0.42ab	3.1 ± 0.47a	2.4 ± 0.34a	11.8 ± 1.04abc
	8	2.1 ± 0.44bc	1.3 ± 0.20	1.1 ± 0.42ab	1.3 ± 0.47ab	1.7 ± 0.34abc	7.8 ± 1.04bc
	13	1.7 ± 0.49bc	0.4 ± 0.23	1 ± 0.47ab	0.06 ± 0.53b	0.03 ± 0.38c	3.4 ± 1.04c
	18	0.9 ± 0.44c	1.2 ± 0.20	0.4 ± 0.42b	0.4 ± 0.47b	0.3 ± 0.34c	3.2 ± 1.04c
2	1	2.5 ± 0.45abc	0.4 ± 0.21	0.8 ± 0.42ab	1.4 ± 0.48ab	1.4 ± 0.34abc	6.3 ± 1.06a
	2	2.6 ± 0.44abc	0.5 ± 0.20	1 ± 0.42ab	1.2 ± 0.47ab	1.4 ± 0.34abc	6.8 ± 1.04a
	3	2.4 ± 0.44abc	0.6 ± 0.20	0.9 ± 0.42ab	1.2 ± 0.47ab	1.4 ± 0.34abc	6.7 ± 1.04a
	8	1.8 ± 0.49bc	0.5 ± 0.23	0.9 ± 0.47ab	0.06 ± 0.53b	0.1 ± 0.38c	3.5 ± 1.17b
	13	1.8 ± 0.49bc	0.5 ± 0.23	0.9 ± 0.47ab	0.06 ± 0.53b	0.1 ± 0.38c	3.5 ± 1.17b
	18	1.8 ± 0.49bc	0.5 ± 0.23	1.4 ± 0.47a	0 ± 0.53b	0.12 ± 0.38c	3.9 ± 1.17b
3	1	1.7 ± 0.49ab	0.5 ± 0.23	0.6 ± 0.47b	0.2 ± 0.53a	0.5 ± 0.38ab	3.6 ± 1.17a
	2	1.7 ± 0.49ab	0.5 ± 0.23	0.8 ± 0.47ab	0.2 ± 0.53a	0.5 ± 0.38ab	3.9 ± 1.17a
	3	1.7 ± 0.49ab	0.9 ± 0.23	0.8 ± 0.47ab	0.5 ± 0.53a	0.5 ± 0.38ab	4.6 ± 1.17a
	8	1.2 ± 0.44c	0.5 ± 0.20	0.7 ± 0.42b	0.2 ± 0.47a	0.05 ± 0.34c	2.7 ± 1.04a
	13	2 ± 0.49abc	0.5 ± 0.23	1.2 ± 0.47ab	0.06 ± 0.53a	0.03 ± 0.32c	4 ± 1.17a
	18	1.2 ± 0.44c	0.9 ± 0.20	2.4 ± 0.42ab	0.35 ± 0.47a	0.1 ± 0.34c	5 ± 1.04a

Values are expressed as mean ± standard error. Means within a column followed by different lowercase letters differ significantly at the 5% significance level. For regrouping 1, observations were made on days 28, 29, 30, 35, 40, and 45 of confinement. For regrouping 2, observations were made on days 56, 57, 58, 63, 68, and 73 of confinement. For regrouping 3, observations were made on days 84, 85, 86, 91, 96, and 101 of confinement.

Table 8. Sociometric variables of dominance hierarchy in first and third regroupings of heifers.

	Regrouping 1				Regrouping 3			
	Lot 1	Lot 2	Lot 3	Lot 4	Lot 1	Lot 2	Lot 3	Lot 4
N	16	19	17	20	20	16	21	20
Number of interactions	60	65	67	331	124	124	256	252
Ratio of interactions to individuals	3.8	3.4	3.9	16.6	6.2	7.8	12.2	12.6
Steepness	0.78	0.78	0.91	0.77	0.85	0.71	0.55	0.66
Proportion of transitive relations (Pt)	1.00	0.00	0.88	0.81	0.90	0.64	0.79	0.77
Triangle transitivity (t_{tri})	1.0	-3.0	0.50	0.23	0.61	-0.5	0.15	0.06
Triangle transitivity's p-value	0.50	1.00	0.27	0.29	0.04	0.78	0.16	0.39

Network graphs can demonstrate the relationships between animals of the same lot. Sociograms were constructed for regroupings 1 (Fig. 4) and 3 (Fig. 5) to assess changes in social interaction. Individual positions were used to identify the most active individuals. Depending on the degree of interaction, the sizes of nodes, each representing an individual, indicate the central role of individuals within the network. Some animals did not perform agonistic interactions and therefore do not appear on the graphs. The animals with barely visible circles had the fewest agonistic interactions and hence the fewest links, indicating that they had minimal influence on group structure. Such cases were observed mainly in lots 1 and 2, which had the lowest number of interactions over time. The greater the number of arrows, the greater the number of interactions. The graphs indicate an increase in interactions from the first to the last regrouping. Community detection was used to identify densely connected groups of individuals by detecting clusters within networks for regroupings 1 (Fig. 6) and 3 (Fig. 7). Thus, after the regrouping, it was possible to determine which group of individuals interacted more often throughout the observation period.

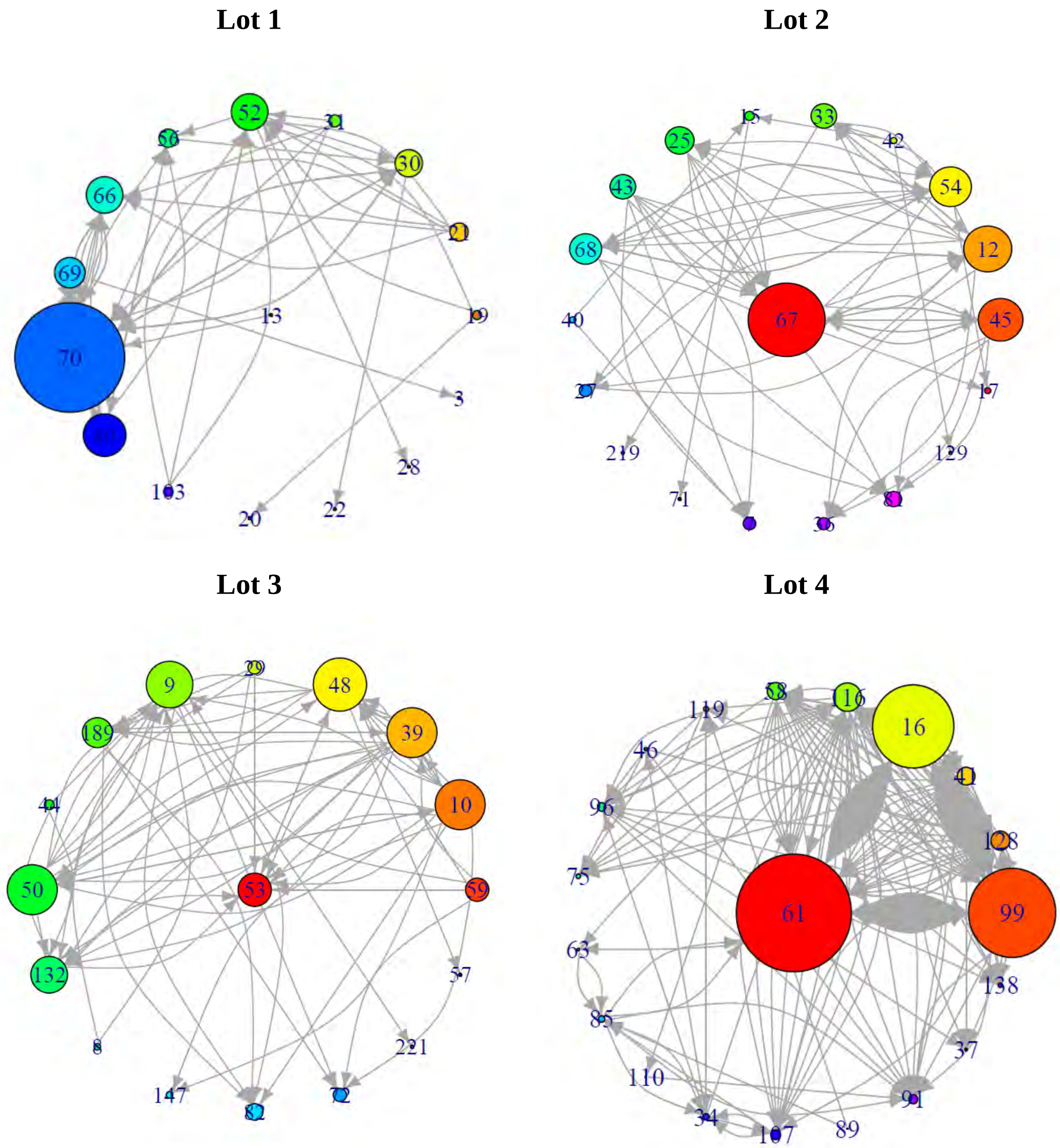

Figure 4. Sociograms illustrating hierarchical networks of feedlot heifers in each lot after the first regrouping. Node size is a function of degree, the larger the degree (a greater number of connections), the larger the node size. Arrows indicate the direction of agonistic interactions (from author to recipient).

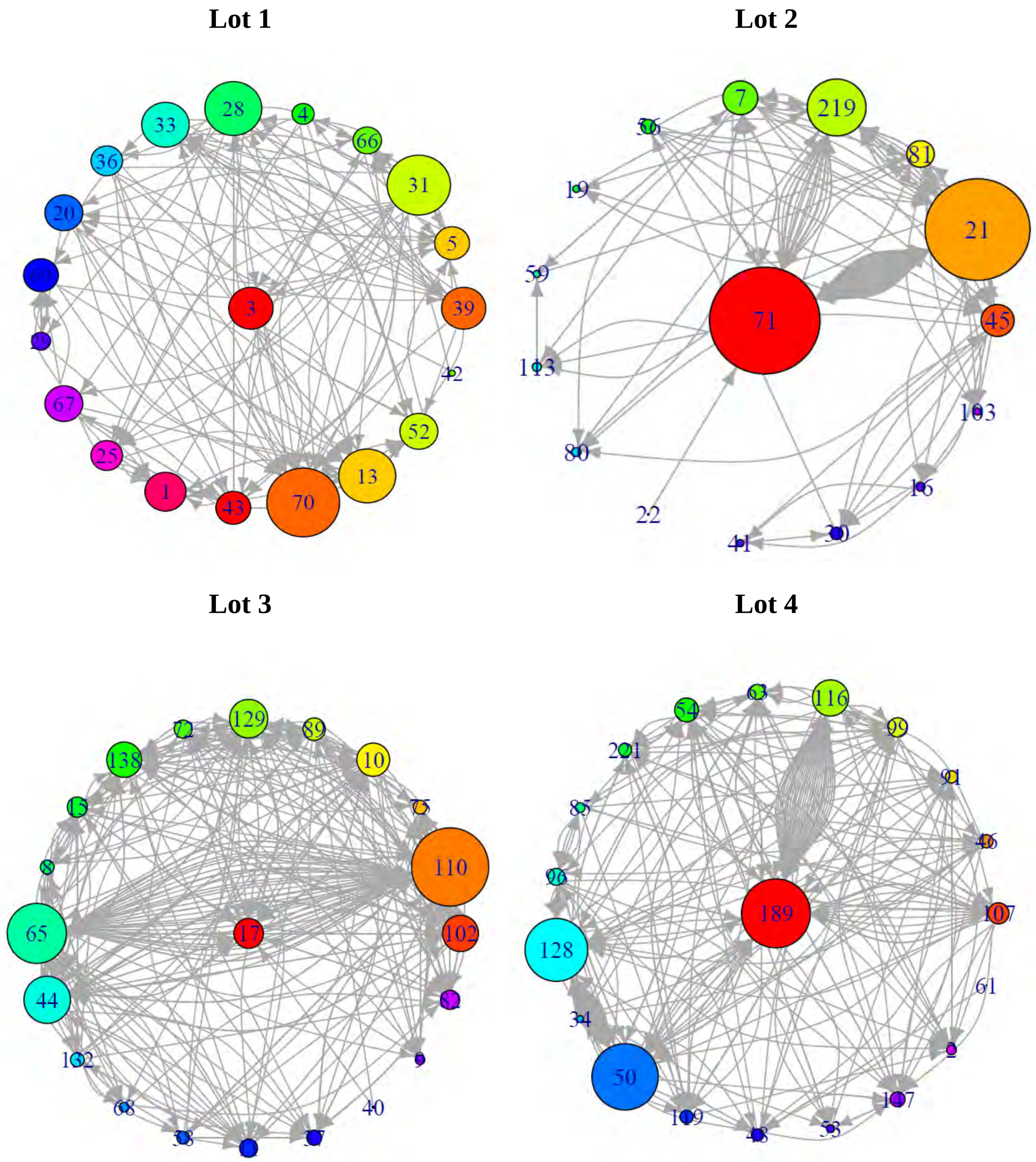

Figure 5. Sociograms illustrating hierarchical networks of feedlot heifers in each lot after the third regrouping. Node size is a function of degree, the larger the degree (a greater number of connections), the larger the node size. Arrows indicate the direction of agonistic interactions (from author to recipient).

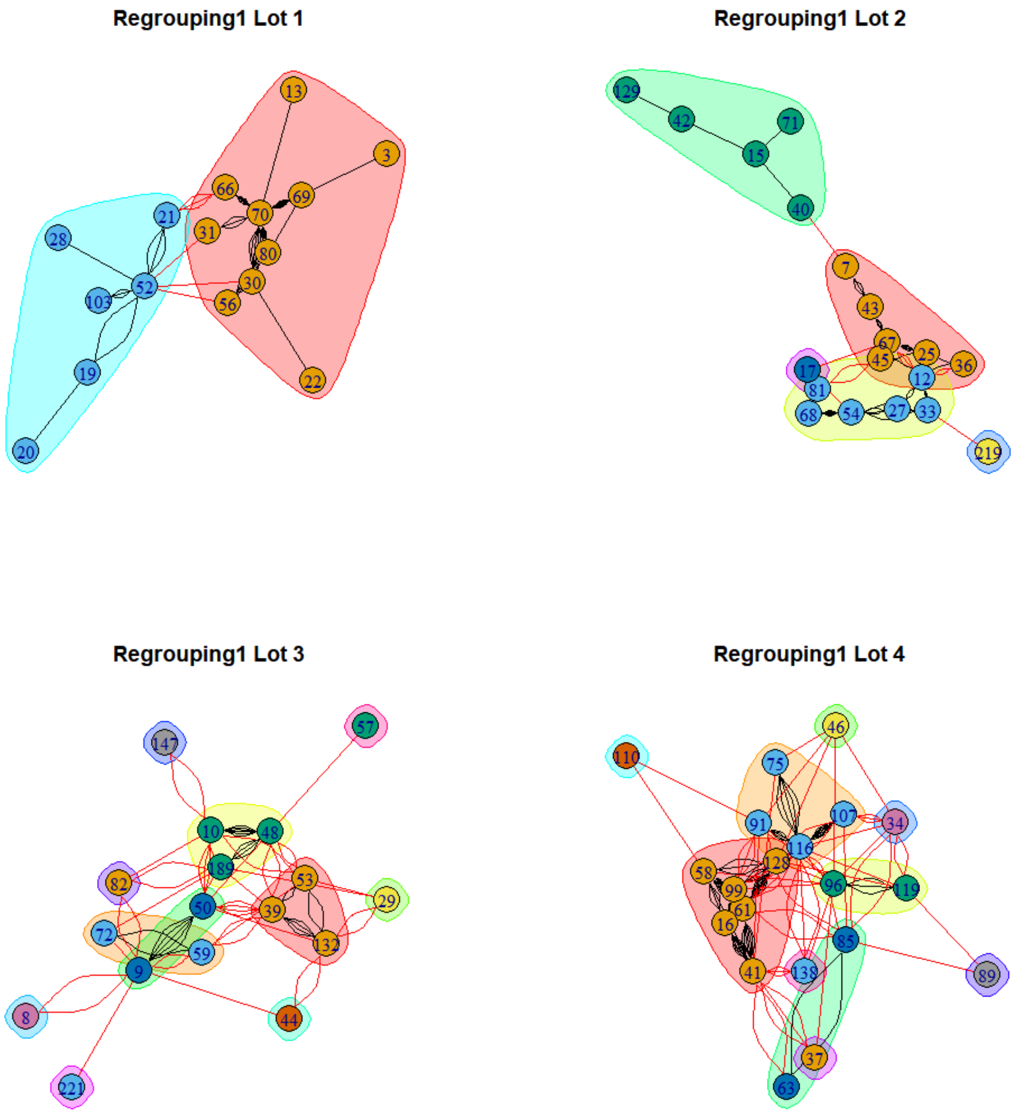

Figure 6. Clusters illustrate densely interacted groups of feedlot heifers after the first regrouping.

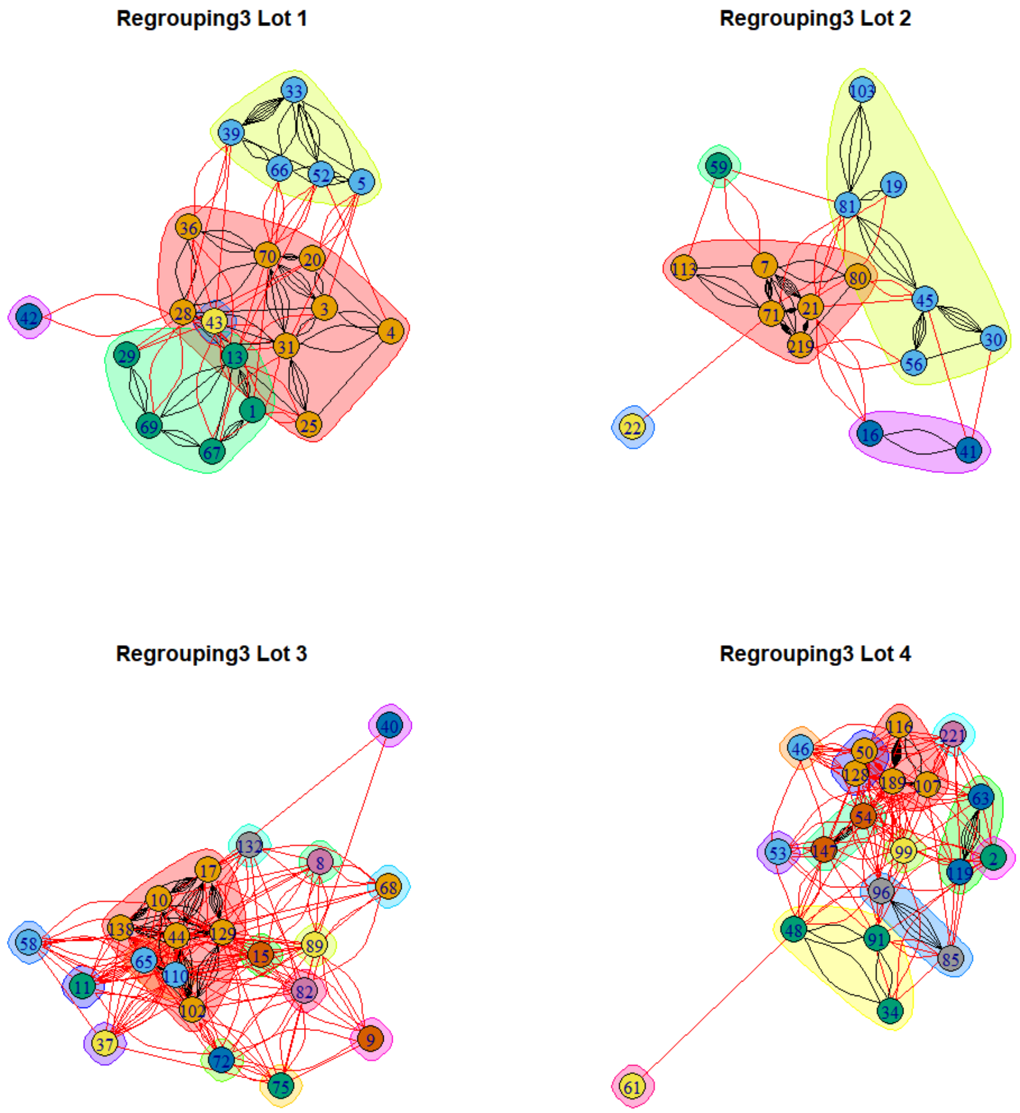

Figure 7. Clusters illustrate densely interacted groups of feedlot heifers after the third regrouping.

On the basis of agonistic interactions, we calculated the dominance score (Elo rating) for each lot within each regrouping (see Appendix). The higher the Elo rating, the higher the social hierarchy within the contemporary group (Table 9).

Table 9. Elo rating of feedlot Angus × Nellore heifers after each regrouping.

Regrouping	Lot	Elo rating		
		Mean	**Maximum**	**Minimum**
1	1	8.5	13.6495	1.432
	2	10	18.481	1.233
	3	9	16.676	1.61
	4	10.5	19.71	1.597
2	1	8	14.995	1.149
	2	3.5	6	1
	3	10	18.64	1.369
	4	9	16.91	2.166
3	1	10.5	17.852	1.227
	2	8.5	15.248	2.967
	3	11	20.082	3.638
	4	10.5	18.625	3.648

Regrouping 1, initial regrouping (day 28); Regrouping 2, day 56; Regrouping 3, day 84. Regroupings were based on liveweight.

The social structure of animals changed in all lots. In lot 1, only one of the initially dominant animals remained so until the end of the experiment. After regrouping 3, the other dominant animals were those that had been initially intermediate. In lot 2, no animals that were initially dominant remained so until the end of regroupings; animals found to be dominant at the end of the experiment were those that had entered the lot after regrouping 2 or 3. In lot 3, two of the initially dominant heifers (regrouping 1) remained dominant until the end of the experiment (regrouping 3), and only one heifer that was initially intermediate became dominant at the end of regroupings. In lot 4, only two initially dominant heifers remained so up to the end of the experiment; the other dominant heifers were those that had entered the lot after regrouping 2 or 3.

The partial correlations between variables show actual associations eliminated from the spurious correlations between variables resulting from the indirect effects of other variables (Fig. 8). Elo score was negatively correlated with interactions in both regroupings. Although there was a significant negative correlation between Elo ratings and BW in the first regrouping, there was no such correlation in the third regrouping. There was a significant correlation between Elo ratings and degree centrality in both regroupings. There was no correlation between BW and reactivity score or exit velocity in the first regrouping. However, there was a negative correlation between BW and both variables after the third regrouping.

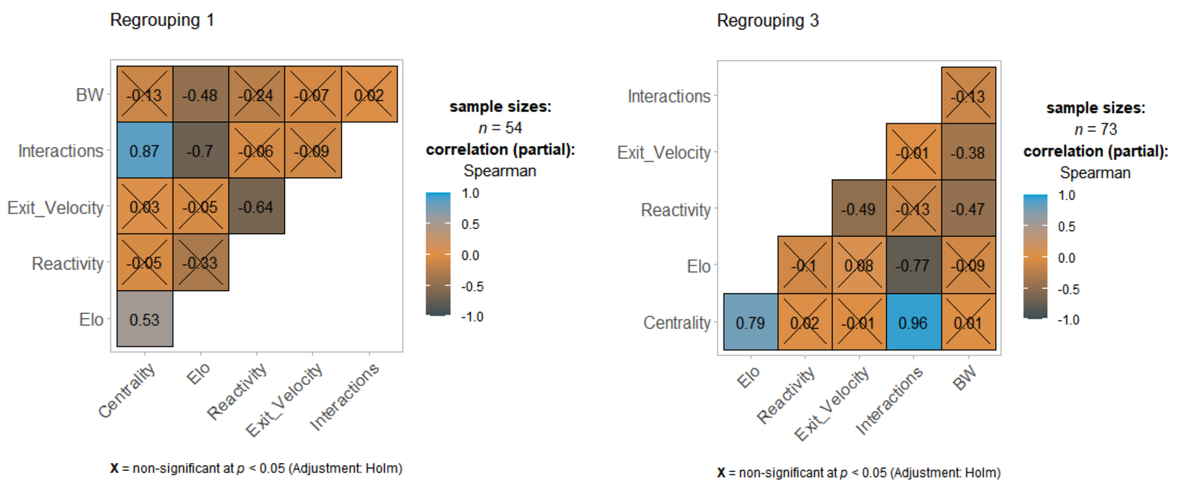

Figure 8. Correlations between variables at the first and third regrouping.

4.3.3. Daily activities

Regrouping influenced the frequency of ruminating, being idle, and performing other activities ($P < 0.01$). Days after regrouping had a significant effect on eating, ruminating, being idle, and performing other activities ($P < 0.01$). Interaction effects were observed on eating, ruminating, idling, and performing other activities ($P < 0.01$) (Table 10). Drinking water was not influenced by regrouping or days after regrouping ($P > 0.12$).

Table 10. Frequency of daily feeding behaviors and activities of feedlot Angus × Nellore heifers at different periods after each regrouping.

Period		Activities				
Regrouping	Day	Eating	Ruminating	Drinking water	Idle	Other activities
1	1	27.7 ± 2.26ab	5.2 ± 0.81b	2.3 ± 0.40b	53.4 ± 2.07b	13.5 ± 0.79b
	2	18.6 ± 1.35c	4.5 ± 0.48b	2.5 ± 0.24b	56.4 ± 1.23b	20.1 ± 0.47a
	3	21 ± 1.35abc	5.2 ± 0.48b	3.0 ± 0.24a	53.4 ± 1.23b	18.9 ± 0.47a
	8	21.8 ± 2.21abc	6.9 ± 0.79ab	2.6 ± 0.39b	68.4 ± 2.02a	2.7 ± 0.78bc
	13	31.6 ± 2.53a	10.3 ± 0.91a	4.7 ± 0.45a	49.9 ± 2.31bc	5.2 ± 0.89bc
	18	21.8 ± 2.53abc	7 ± 0.79ab	2.6 ± 0.39b	68.5 ± 2.02a	2.7 ± 0.78bc
2	1	14.4 ± 2.26bc	11.9 ± 0.81a	1.9 ± 0.40a	68.2 ± 2.07a	3.4 ± 0.79a
	2	20.9 ± 1.82a	10.8 ± 0.65a	1.9 ± 0.32a	66 ± 1.66a	0.4 ± 0.64b
	3	23.4 ± 1.66a	10.5 ± 0.60a	2 ± 0.29a	63.7 ± 1.52a	0.5 ± 0.58b
	8	18.8 ± 2.21a	11.3 ± 0.79a	1.7 ± 0.39a	63.5 ± 2.02a	4.3 ± 0.78a
	13	29.4 ± 2.53a	9.2 ± 0.91a	2.6 ± 0.45a	57.9 ± 2.31a	0.6 ± 0.89a
	18	27.4 ± 2.21a	10.5 ± 0.79a	1.3 ± 0.39a	58.2 ± 2.02a	2.4 ± 0.78a
3	1	25.2 ± 2.16a	11.1 ± 0.77a	1.7 ± 0.38a	41.0 ± 1.97a	12.7 ± 0.76b
	2	18.6 ± 1.35a	4.5 ± 0.48b	2.3 ± 0.24a	56 ± 1.29a	20.1 ± 0.47a
	3	21.3 ± 2.22a	5.2 ± 0.48b	3.1 ± 0.24a	52.4 ± 1.23a	18.5 ± 0.47a
	8	21.8 ± 2.21a	6.9 ± 0.79b	2.6 ± 0.39a	68.4 ± 2.02a	2.7 ± 0.78bc
	13	22.3 ± 2.53a	6.5 ± 0.91b	2.8 ± 0.45a	68.3 ± 2.31a	2.6 ± 0.89bc
	18	21.3 ± 2.21a	6.9 ± 0.79b	2.6 ± 0.39a	65.3 ± 2.02a	6.2 ± 0.78bc

Values are expressed as mean ± standard error. Means within a column followed by different lowercase letters differ significantly at the 5% significance level. For regrouping 1, observations were made on days 28, 29, 30, 35, 40, and 45 of confinement. For regrouping 2, observations were made on days 56, 57, 58, 63, 68, and 73 of confinement. For regrouping 3, observations were made on days 84, 85, 86, 91, 96, and 101 of confinement.

4.3.4. Animal performance

As expected, there was an interaction effect of regrouping and lot on performance variables ($P < 0.01$) (Table 11). The total weight gain was 101 kg, and body weight increased throughout confinement. Lots were divided so as to maintain differences in mean body weight;

nevertheless, some lots did not differ significantly in body weight (P > 0.05), especially intermediate-weight lots. Differences were lower after the second regrouping. Regrouping and lot exerted significant interaction effects on daily weight gain (P < 0.01), with the highest gains at the beginning of confinement. The main effects of regrouping (P < 0.01) and lot (P < 0.01) were also significant for daily weight gain.

Table 11. Body weight and daily weight gain of feedlot Angus × Nellore heifers after each regrouping.

Regrouping	**Weight**	**Lot**	**Weight**	**Daily weight gain**
1	353c ± 2.36	1	378.2 ± 4.81a	2.5 ± 0.10a
		2	362.5 ± 4.69ab	2.5 ± 0.09a
		3	344.7 ± 4.69bc	2.4 ± 0.09a
		4	326.6 ± 4.69c	2.2 ± 0.09ab
2	401.9b ± 2.44	1	445.4 ± 4.59a	2.0 ± 0.09a
		2	407.4 ± 4.94b	1.9 ± 0.09ab
		3	387.5 ± 4.94bc	1.7 ± 0.09bc
		4	367.2 ± 5.07c	1.8 ± 0.10bc
3	451.4a ± 2.41	1	498.6 ± 4.69a	1.6 ± 0.09a
		2	459 ± 5.22b	1.5 ± 0.10ab
		3	436.9 ± 4.69b	1.4 ± 0.09bc
		4	411 ± 4.69c	1.3 ± 0.09c

Values are expressed as mean ± standard error. For each regrouping, means within a column followed by different lowercase letters differ significantly at the 5% significance level.

4.4. DISCUSSION

Regrouping is a common practice in intensive livestock production; however, it should be avoided in commercial feedlots, as this management practice tends to destabilize the social structure of herds. Animal temperament has been increasingly investigated, given the need to select animals that are less reactive to daily management practices and exhibit low aggressiveness, contributing to minimizing the risks of injury and death to animals and handlers while promoting gains in productivity (OLSON et al., 2019; GELLATLY et al., 2020). Adequate handling techniques aimed at animal welfare are effective in reducing reactivity (TITTO et al., 2010). In male cattle, the lack of regrouping promoted a decrease in reactivity score after 120 days of confinement (TONON, 2020). Similarly, heifers had lower reactivity before aversive handling (CEBALLOS et al., 2018). In the present study, heifers showed higher reactivity after regrouping, with an increase of 0.5 in reactivity score. Of note, the observed reactivity scores were still within the normal range (less than 3) (TITTO et al., 2010).

The increase in reactivity likely occurred because of the induced regroupings, which promoted agonistic behaviors in pens, socially disrupting lots and increasing the occurrence of stressful situations during handling. According to Makagon et al. (2012), some individuals are more affected by social stress, inducing new responses or new information and thereby influencing group behavior, affecting the group's ability to deal with stress and solve simple daily problems, such as taking turns at the trough. It should be noted that the use of a 5-point scale to assess reactivity in cattle (KARAMFILOV, 2022) tends to afford values close to the average; an even-numbered scale, as used in the current study, is more suitable for identifying extremes within a group of animals.

Exit velocity was also higher at the end of the experimental period. By associating this result with that of reactivity, it is inferred that animals did not become habituated to handling practices, differing from the observations of Gellatly et al. (2020) and Titto et al. (2010). The authors reported that frequent handling may reduce animal excitability over time. In the first regrouping, there was no significant correlation between BW and reactivity score or exit velocity. However, in the third regrouping, there was a negative correlation between BW and both variables, suggesting that the reactivity of these animals decreased with increasing BW or habituation to the handling procedure over time. Other studies showed that exit velocity reduces throughout confinement or with increasing age, with mean values ranging from 0.85 to 1.19 m s^{-1} after adaptation (ALMEIDA, 2018; TONON, 2020). In the current study, animals were allocated to pens with other animals from the same farm at a stocking density below the recommended threshold, two beneficial characteristics for minimizing negative interactions.

In general, lots with the heaviest animals were those that had the lowest incidence of agonistic interactions throughout confinement. However, in our study there was no correlation between body weight and agonistic interactions. These results differ from those of Mounier et al. (2005), who studied homogeneous and heterogeneous lots of bulls regarding weight and age. The authors found that homogeneous lots had higher frequency and duration of agonistic interactions and lower synchronized feeding behaviors within paddocks.

The frequency of agonistic behaviors was found to decrease in the days following regroupings; the lowest frequency of such interactions was observed after regrouping 3. In homogenous cattle lots, the incidence of positive behaviors such as licking and head play are known to increase over time (MOUNIER et al., 2005); thus, despite the frequent changes in lot members, it is possible that regrouped animals became familiar with previous lot mates, contributing to a reduction in agonistic interactions over time.

Mounting may be considered a nonaggressive behavior that is not associated with dominance in female cattle. Such behavior may be associated with affiliative interactions between individuals and serves as an indicator of estrus (MOHAN RAJ et al., 1991). Here, the frequency of mounting did not differ throughout regroupings. Tennessen et al. (1985) stated that the number of mounts following the exit or entry of new individuals in lots is high but may reduce as the social structure is established; agonistic behaviors tend to reduce up to 10 days after changes. Mounting associated with aggressiveness is more common in young than in older cattle (TENNESSEN et al., 1985).

The highest frequency of agonistic interactions was observed on the three days following the second regrouping compared with subsequent days. After this period, there was a rapid stabilization of the social structure, demonstrating the strong decreasing tendency of agonistic interactions over time after regrouping (MOUNIER et al., 2005).

Regrouping can destabilize the predefined social structure of cattle, as was observed in this study. In cattle, when few changes are made to the number of individuals in a lot, disputes are resolved rapidly. Bettencourt (2021) argued that a stable social hierarchy in cattle is formed within up to a week, similar to our findings. The time for stabilization of the social hierarchy in cattle herds, however, is not yet well defined. Previous studies reported that social reorganization occurs within 24 to 72 h after the change in structure (BOUISSOU, 1974). In our study, the number of agonistic interactions was still high up to 35 h after regrouping, with a marked reduction in agonistic interactions from the eighth day after regrouping onward. In this study, triangle transitivity used as the linearity measure for the hierarchy. The transitive triangles can be slightly negative when the random expected proportion of transitive triangles is less than 0.75 (McDonald and Shizuka, 2012). In both regroupings in Lot 2, the triangle transitivity was negative, indicating that relations between the heifers in these groups were not transitive but rather more cyclic, a particular form of triad in which directional relations form a cycle, e.g., A dominates B, B dominates C, and C dominates A (Shizuka and McDonald, 2012).

Social network graphs revealed continuous, bidirectional behaviors between certain individuals, more specifically, dyad disputes, demonstrating the non-stabilization of the dominance hierarchy among individuals (HASENJAGER; DUGATKIN, 2015). According to Newman (2003), social network graphs may be used to represent an individual within a group and its proximity and bidirectional behaviors toward others, where there are symmetries or reciprocities of behaviors. These types of behaviors are often affiliative, but, in the case of the current study, they were agonistic. In the current study, there was a significant correlation between Elo ratings and degree centrality in both regroupings, indicating that dominant animals also play a central role in agonistic interaction networks. The groups of heifers, on the other hand, exhibited a very flat and non-transitive hierarchy. Therefore, estimates of rank order are quite uncertain. It is more probable for upsets to result in overall rank changes when hierarchies are not steep (McDonald and Shizuka, 2012). Given that the number of recorded interactions per individual, except for Lot 4, falls outside of the suggested range of 10–20 (Sanchez-Tojar et al., 2018), this scenario is likely to change if more data is collected. Despite the low ratio of interactions to individuals in the present study, this finding reinforces the hypothesis of little or no stability in social dominance hierarchy after regroupings. Although the few studies on young heifers that regrouped throughout confinement showed no negative impact on animal performance, this type of management practice should be avoided to prevent subjecting animals to chronic stress factors.

Here, eating was influenced by regrouping and days after regrouping. As discussed by Mounier et al. (2005), there is a tendency for animals to synchronize their activities because of hierarchical factors or in the case of limited resources, to minimize trough disputes and ensure equal consumption. Regrouping was also found to influence idle behaviors, rumination frequency, water consumption, and exploratory or affiliative activities, and such changes might be associated with greater attention or vigilance during the period of social restructuring (BRUNO et al., 2018).

The number of fights and trough disputes was lowest on the days following regrouping, as was the number of agonistic interactions. These days were also the ones with the highest number of animals drinking water and feeding. Gellatly et al. (2020) observed that, in environments with little or no competition, cattle may spend more time feeding than performing any other activity. Similarly, we observed more disputes after regrouping, with a change in behavior over time.

Being idle had the highest frequency of occurrence (>50%) during regroupings, followed by eating (22%). The frequency of eating was similar between lots and between days after regrouping. In assessing differences between days within each regrouping, it was observed that eating frequency varied over the 18 days of evaluation, with a slight tendency to increase after the first day. Regrouping also influenced the frequency of affiliative and exploratory activities, which were lower one week after regrouping.

In the present study, the lots with the highest number of interactions were those with weight gains below the estimated for the basal diet (1.5 kg animal^{-1} day^{-1}). According to Bettencourt (2021), there is a negative relationship between rupture of social structure and animal productivity. Animals have a lower feed intake when the frequency of disputes is high, which increase energy expenditure. However, there was no relationship between social status and performance, differing from the results of Haskell et al. (2019). The authors observed that highly dominant steers tended to visit troughs more frequently ($P = 0.07$).

There are few studies measuring the effects of social status on the temperament and performance of feedlot heifers. According to Bruno et al. (2018), the relationship between social status and performance in confined cattle is not clear, given that the few results on this topic are controversial (MOUNIER et al. 2005; BRUNO et al., 2018; BETTENCOURT, 2021).

Mean daily weight gains were more significant at the beginning of confinement, before regrouping, but this result may be linked to a compensatory gain (GELLATLY et al., 2020). At the end of regroupings, the two lots with the heaviest animals had mean daily weight gains equal to or above the expected. Animals from the other lots had to remain in confinement for one and a half months longer to reach the slaughter weight.

4.5. CONCLUSION

Regrouping animals for lot standardization by weight throughout confinement promoted negative changes in reactivity. Despite the decrease in agonistic interactions over time after regrouping, this practice affected the performance of lower-weight heifers. Heavier animals had the lowest frequency of agonistic behaviors throughout confinement. Bidirectional interactions were observed in some lots after regrouping, indicating instability of the dominance hierarchy of lots.

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Supplementary material

Dominance score (Elo rating) and hierarchical rank of each animal per lot after each regrouping.

Lot 1											
Regrouping 1				Regrouping 2				Regrouping 3			
Animal	Elo rating	Rank	Status	Animal	Elo rating	Rank	Status	Animal	Elo rating	Rank	Status
22	13.6495	1	d	42	14.995	1	d	66	17.852	1	d
28	13.3315	2	d	5	13.965	2	d	70	17.631	2	d
70	13.271	3	d	13	12.198	3	d	13	17.088	3	d
30	12.94	4	d	28	11.95	4	d	1	17.046	4	d
3	11.548	5	d	52	11.41	5	d	52	16.51	5	d
66	10.752	6	i	219	9.776	6	i	5	16.049	6	d
20	10.342	7	i	20	8.949	7	i	69	14.454	7	i
52	9.805	8	i	70	7.66	8	i	33	12.958	8	i
56	9.785	9	i	39	7.104	9	i	43	10.954	9	i
69	7.379	10	i	33	6.885	10	i	25	10.867	10	i
13	6.61	11	s	27	4.318	11	s	20	9.263	11	i
80	4.551	12	s	43	4.261	12	s	29	9.066	12	i
31	3.715	13	s	1	3.367	13	s	39	7.964	13	i
103	3.667	14	s	31	2.013	14	s	67	7.629	14	s
19	3.222	15	s	3	1.149	15	s	28	5.621	15	s
21	1.432	16	s					36	5.585	16	s
								3	5.547	17	s
								42	3.436	18	s
								4	3.253	19	s
								31	1.227	20	s

Lot 2											
Regrouping 1				Regrouping 2				Regrouping 3			
Animal	Elo rating	Rank	Status	Animal	Elo rating	Rank	Status	Animal	Elo rating	Rank	Status
81	18.481	1	d	80	6	1	d	103	15.248	1	d
36	17.914	2	d	19	4.5	2	d	30	14.912	2	d
17	16.312	3	d	16	4.5	3	i	80	12.761	3	d
71	15.258	4	d	113	2.5	4	i	45	10.682	4	d
7	15.216	5	d	89	2.5	5	s	41	10.574	5	d
219	12.6385	6	d	36	1	6	s	16	9.856	6	i
129	12.637	7	d					113	9.291	7	i
15	10.7995	8	i					81	9.231	8	i
67	9.915	9	i					19	8.336	9	i
45	8.338	10	i					219	7.82	10	i
27	8.008	11	i					21	7.188	11	i
25	7.741	12	i					59	7.055	12	s
68	7.605	13	i					7	3.562	13	s
54	7.094	14	s					22	3.492	14	s
12	6.74	15	s					71	3.025	15	s
33	5.325	16	s					56	2.967	16	s
40	4.649	17	s								
42	4.096	18	s								
43	1.233	19	s								

Lot 3											
Regrouping 1				Regrouping 2				Regrouping 3			
Animal	Elo rating	Rank	Status	Animal	Elo rating	Rank	Status	Animal	Elo rating	Rank	Status
82	16.676	1	d	110	18.64	1	d	82	20.082	1	d
72	15.48	2	d	132	16.086	2	d	75	17.991	2	d
53	14.708	3	d	57	15.308	3	d	11	17.396	3	d
221	13.0175	4	d	72	14.633	4	d	9	13.706	4	d
132	12.201	5	d	82	13.887	5	d	65	13.412	5	d
57	11.7525	6	i	2	13.778	6	d	72	13.019	6	d

9	11.292	7	i	17	12.96	7	d	17	12.856	7	d
189	10.489	8	i	45	11.849	8	i	138	12.586	8	i
147	9.818	9	i	138	10.944	9	i	37	12.445	9	i
48	8.747	10	i	54	10.751	10	i	129	12.301	10	i
50	6.121	11	i	129	9.822	11	i	68	12.081	11	i
8	5.84	12	s	37	9.322	12	i	110	11.195	12	i
44	5.309	13	s	75	8.046	13	i	10	10.479	13	i
29	4.31	14	s	99	7.033	14	s	102	8.383	14	i
39	3.659	15	s	58	4.915	15	s	44	8.213	15	s
10	1.97	16	s	102	4.104	16	s	15	7.936	16	s
59	1.61	17	s	65	3.301	17	s	132	7.257	17	s
				40	3.252	18	s	89	6.77	18	s
				9	1.369	19	s	58	5.308	19	s
								40	3.946	20	s
								8	3.638	21	s

Lot 4

Regrouping 1				Regrouping 2				Regrouping 3			
Animal	Elo rating	Rank	Status	Animal	Elo rating	Rank	Status	Animal	Elo rating	Rank	Status
91	19.71	1	d	189	16.91	1	d	147	18.625	1	d
138	18.526	2	d	221	15.626	2	d	2	18.618	2	d
37	17.775	3	d	53	13.523	3	d	91	16.862	3	d
96	14.828	4	d	107	11.621	4	d	53	16	4	d
75	14.48	5	d	91	11.41	5	d	128	13.366	5	d
107	14.083	6	d	147	10.956	6	i	221	12.991	6	d
16	13.206	7	i	48	10.327	7	i	119	12.841	7	i
119	11.22	8	i	50	9.921	8	i	54	11.91	8	i
34	11.041	9	i	11	8.749	9	i	99	10.343	9	i
110	10.29	10	i	119	8.095	10	i	63	9.905	10	i
128	9.944	11	i	128	7.733	11	i	189	9.839	11	i
85	9.297	12	i	116	7.597	12	s	50	9.672	12	i
63	8.726	13	i	46	7.507	13	s	48	9.344	13	i
46	7.285	14	i	85	4.774	14	s	96	8.763	14	i

61	7.072	15	s	34	3.539	15	s	34	6.842	15	s
41	6.962	16	s	96	2.546	16	s	61	6.415	16	s
116	5.991	17	s	63	2.166	17	s	107	5.456	17	s
89	4.09	18	s					46	4.774	18	s
99	3.877	19	s					85	3.786	19	s
58	1.597	20	s					116	3.648	20	s

d, dominant; i, intermediate; s, subordinate.

5. FINAL CONSIDERATIONS

There are several advantages to finishing cattle in feedlots, and they are even greater than the disadvantages of cattle breeders. However, from a behavioral point of view, disputes, threats, lack of synchronicity among the animals at the trough, and lack of social contribution among the groups generated destabilization in the hierarchy of the groups.

Throughout these studies, changes in animal behavior were observed. Partial regrouping in the number of animals delayed the finishing of the animals for slaughter by an average of one month, which is a problem for confiners. The most negative effects were observed in the regrouped animals. We observed a greater reactivity of the animals to simple handling of vaccination, weighing, and deworming, always after the changes in individuals in the flocks, that is, it is hypothesized that these animals, by not knowing each other or identifying their flock mates, increased their reactivity responses. This factor is a potentially harmful stressor for animals, contemporaneous or regrouped in the flocks, because there is the possibility of increased fighting and accidents between the herdsman and the animals being herded due to the altered perception of constancy of the animals during herds.

Another frequently observed factor was the asymmetry of the duration in days or hours for reestablishment with "reduction" of fights and group hierarchy after regrouping. Based on our results, it is possible to say that it took up to a week on average for agonistic behaviors to reduce in flocks. Like flocks with a stable hierarchy, there were many behaviors summarized in dyads or triads, and after regrouping, the frequencies in agonistic behaviors were general, directed toward regrouped or ungrouped animals.

Therefore, we suggest the need for further studies on the incidence of this practice in feedlots and evaluation of the costs involved.