



doi: <https://doi.org/10.36812/pag.202329148-61>

ORIGINAL ARTICLE

BovCria: an application designed to assist breeders in the assessment of beef cattle herds

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Abstract - The aim of this study was to develop a technological tool in the form of a mobile application that provides functionalities for the easy calculation of reproductive and productive efficiency indices. This tool aims to assist breeders, technicians, and students of agricultural sciences in decision-making for the challenges faced in cattle production systems. The application was developed using the Android Studio development environment and the Dart programming language framework known as Flutter. The application's graphical interface follows Google guidelines in the Material Design documentation. The tool will provide a practical way to calculate recognized indexes of productive efficiency of cow-calf systems and provide information such as goals and management tips to help users achieve better results. The impact of the developed product is its use as an information platform, facilitating decision-making in the area of beef cattle production and as an efficient means of disseminating technologies generated by research institutions and popularizing science. Thus, the application is an accessible and comprehensible tool, providing a means of evaluating the technologies and management practices adopted in beef cattle farms.

Keywords: Mobile app. Livestock. Beef cattle productivity. Zootechnicals rates. Digital technology.

Aplicativo BovCria: desenvolvido para auxiliar criadores na avaliação de rebanhos de bovinos de corte

Resumo - O objetivo deste estudo foi o desenvolvimento de ferramenta tecnológica sob a forma de um aplicativo móvel disponibilizando funcionalidades que permitem o cálculo facilitado de índices de eficiência reprodutiva e produtiva, auxiliando criadores, técnicos e estudantes de ciências agrárias na tomada de decisão face aos desafios dos sistemas produtivos de bovinos de corte. O aplicativo foi desenvolvido no ambiente de desenvolvimento do *Android Studio*, fazendo uso do *Framework* para a linguagem de programação *Dart* conhecido como *Flutter*. A interface gráfica do aplicativo segue as diretrizes do *Google* conforme documentação do *Material Design*. Fornecerá uma forma prática de calcular índices reconhecidos de eficiência produtiva em rebanhos de cria e informações tais como metas e dicas de manejo para que os usuários possam alcançar melhores resultados. O impacto do produto desenvolvido consiste na utilização de software como plataforma de informação, verificação e tomada de decisão na área de bovinos de corte e como meio ágil de divulgação das tecnologias geradas pelas instituições de pesquisa e popularização da ciência. Assim, o aplicativo é uma ferramenta de fácil acesso e compreensão, proporcionando um meio de avaliação das tecnologias e do manejo adotados nas propriedades rurais de bovinos de corte.

Palavras-chave: Aplicativo móvel. Pecuária. Produtividade de bovinos de corte. Índices zootécnicos. Tecnologias digitais.

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Introduction

In 2020, Brazil's Gross Domestic Product fell by 4.1 % compared to the previous year. In contrast, the beef cattle GDP grew by 20.8 % in the same year, totaling BRL 747.05 billion (ABIEC, 2021). The greater internal and external demand for various agricultural and livestock products, the appreciation of prices, and increased production were factors that contributed to the growth of the sector. The Brazilian herd of cattle, the second largest in the world, reached a record of 187.55 million heads in 2020 (ABIEC, 2021). However, there is a need to improve productivity rates in the sector.

The potential of Brazilian livestock farming is indisputable. However, the use of technological tools can optimize animal production and increase the modernization of the sector's management, ultimately leading to successful outcomes. The productivity of beef cattle is highly dependent on the performance of the cow-calf system in the production of calves. Figure 1 systematically presents the interrelationships between management, strategic factors, and performance evaluation indices in the cow-calf system, as well as the rearing and finishing phases of the livestock cycle.

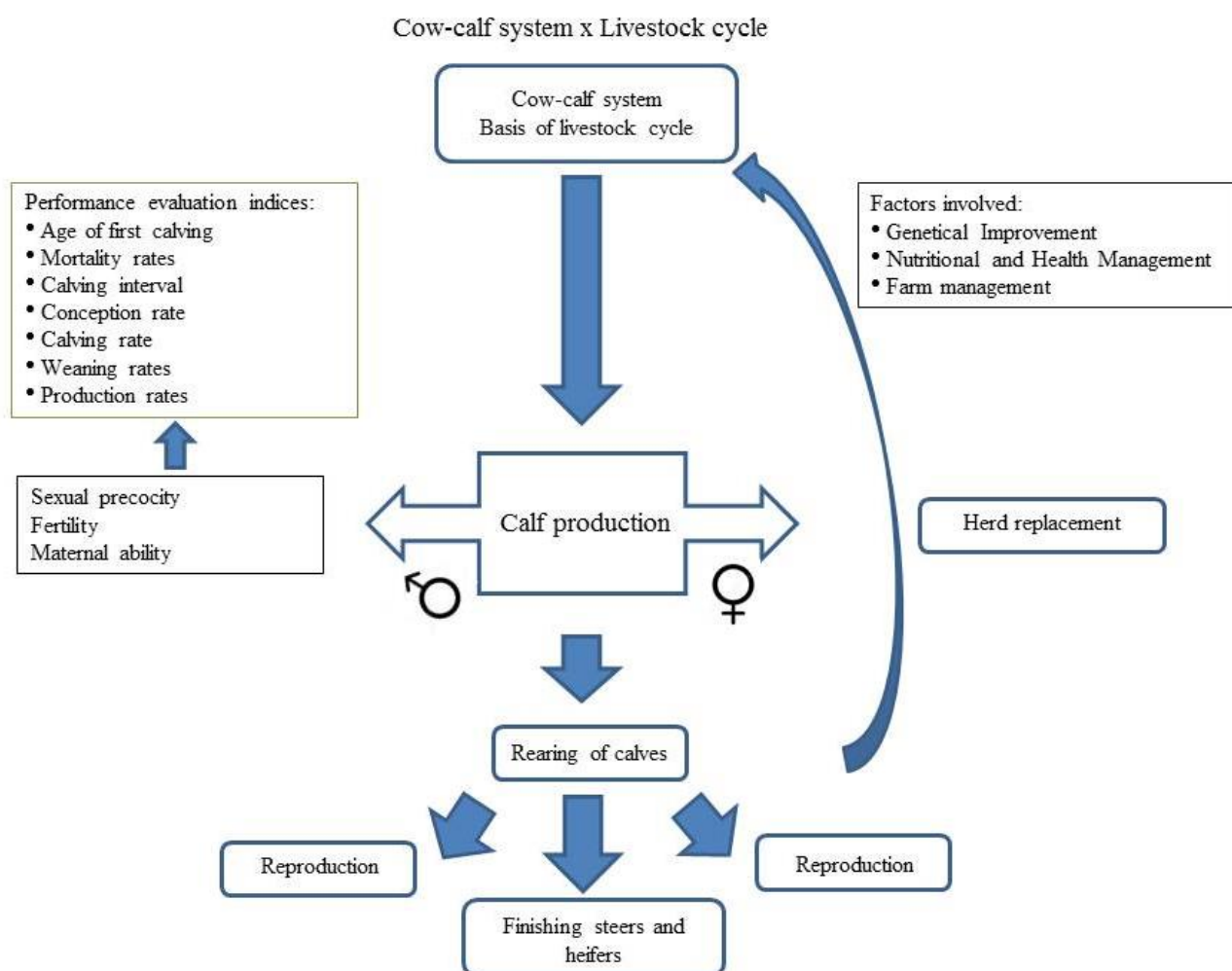


Figure 1. Interrelationships among management, strategic factors, and performance evaluation indices in the cow-calf system, as well as the rearing and finishing phases of the livestock cycle.



According to Costa and Pereira (2013), Brazilian beef cattle ranchers are unaware of even the most basic zootechnical indices of the activity, such as the conception rate and herd mortality. The low productivity rates of the Brazilian cattle herd (Table 1) indicate a pressing need for the implementation of performance evaluation technologies by ranchers. The lack of knowledge and low rates found contribute to low productive and reproductive efficiency, and are further exacerbated by difficulties in transferring technologies generated by research to the field (GONÇALVES *et al.*, 2021; ALVES *et al.*, 2019; FERRAZ and FELÍCIO, 2010; RESENDE *et al.*, 2010).

Table 1. The average values of the primary zootechnical indices for the Brazilian herd and the recommended targets.

Zootechnical indices	Brazilian average	Recommended goal
Age at first calving (month)	48 a 60	24
Interval between calving (month)	21	12
Annual general mortality rate (%)	4	1
Annual mortality rate of calves until weaning (%)	8	2
Conception rate (%)	60	≥ 90
Weaning rate (%)	54	≥ 88

Source: Adapted from Zimmer and Euclides Filho (1997).

In recent years, internet access in rural areas has increased, as has the use of smartphones in farmers' daily routines. As a result, digital tools can be utilized to promote the adoption of zootechnical indices for performance evaluation, as well as to aid in disseminating technologies generated by teaching and research institutions.

A survey was conducted in 2021 to identify mobile applications (apps) that were available in Portuguese, free of charge and focused on beef cattle and productivity (GONÇALVES *et al.*, 2021). Keywords such as "beef cattle" and "productivity" were used to search for apps on both Android and iOS platforms. The Google Play Store and Apple Store online stores, which are the official application download channels, were used to collect data. A total of 23 apps were found, out of which 18 (78 %) were developed by private companies and the remaining 5 were developed by public institutions. Thirteen of the apps were free, while the others charged a fee for using certain functions. Most of the apps were made available from 2017 onwards, which suggests a growing demand for such tools in the livestock sector. The high number of downloads of these apps on the analyzed platforms (7 apps had more than 10,000 downloads, 4 had more than 5,000, 5 had more than 1,000, 2 had more than 500, 3 had more than 100, and 2 had more than 10) indicates their significant reach in animal production and their importance as a vehicle for disseminating technical knowledge (ALVES *et al.*, 2019; GONÇALVES *et al.*, 2021).

Considering the low number of applications developed by the public sector and the need to meet the demands of the agricultural sector, a specific free application for cow-calf systems was developed. This includes calculations of rates, informative tables for comparisons, and management tips aimed at increasing



production, providing a didactic, agile, and fast way to use and disseminate technologies generated by research.

Material and Methods

The measurement of performance is key in farm management, as performance is partly a result of decisions taken. Quality is affected by both the quantity and quality of information generated by zootechnical indicators (BOND, 2002). El-memare Neto (2019) states that the numbers and indices of a farm must be intelligent, meaning that they should be measurable, necessary, global, comparable, didactic, effective, and simple to calculate. This enables management to quickly access information and intervene in the production system. The study by Rosado Jr. and Lobato (2010) discusses six characteristics that adequate indicators should possess, but only four of them refer to the intrinsic aspects of the indicator: (1) objectivity; (2) ease of measurability; (3) timely responses; and (4) availability to decision-makers.

In this context, the zootechnical indices available in this mobile application are widely recognized as performance assessment tools in breeding herds. The purpose of using this information is to assist the producer in achieving their goals and improving their results. Consequently, these indices also enable more sustainable use of the area occupied by livestock activity.

The available indices in the app

Age at first calving and interval between calving

The first index considered in the content is the age at first calving, as it represents one of the main performance factors of the cow-calf system's female population. By entering the age at first calving in months, the user can receive a response regarding the situation of their herd compared to the ideal goal. Additionally, specific tables containing recommended indices (referred to as goals) and management tips to improve results can be accessed. To calculate the interval between calving, the user can enter the dates for two consecutive calving events, with the result being presented in days. Specific tables for comparisons and management tips will also be made available to the user.

Annual general mortality rate of the herd and annual mortality rate of calves until weaning (%)

The first rate refers to the ratio between the number of dead animals and the total number of heads in the herd. The second rate is obtained by calculating the difference between the number of calves weaned and the number of calves born, divided by the number of calves born. These two rates enable the assessment of nutritional efficiency and health management across all categories of the herd, as well as overall property management. The results are generated as percentages, and the application indicates the verification against the indices presented in specific tables and provides management tips.

Conception rate (%)

The ratio between the number of pregnant females and the number of inseminated or mated females is



referred to as pregnancy rate. This rate represents the result of adopting techniques related to female fertility, nutritional and health management, reproductive management, and general farm management.

Calving rate (%)

Calving rate refers to the ratio between the number of calving females and the number of pregnant females. The health status and management of the herd is evaluated through this rate, and it is possible to differentiate between categories, with the user having to select it to compare the result obtained in the table of goals for reproductive indices.

Weaning rate (%)

The mobile application considers the number of calves weaned and the number of pregnant females to evaluate the maternal ability of cows, handling of newborns, and other sanitary and nutritional management practices for young animals. The app provides a comparison with goals available in a specific table, access to management tips, and a shortcut "Did you know that..." presenting relevant information related to factors that determine the efficiency of cow-calf systems. The results of the three rates are given in percentages, allowing for an evaluation of cow performance, including fertility, maternal ability, efficiency of genetic selection, and adopted reproductive technologies and management practices.

Ratio calf/ cow (%)

The app provides information on the percentage of live weight of the cow converted into kg of calf weight at weaning. To obtain this information, the user needs to input the weight of the weaned calf and the weight of the cow at weaning. This enables an evaluation of the maternal ability and nutritional management of the cow and her calf.

Actual production of kg of weaned calf/cow/year (kg)

The app calculates this rate by dividing the weight of the weaned calf in kg by the interval between calving in days of the dam, with the result given in kg. The application indicates a minimum value of 170 kg and suggests accessing the "handling tips" shortcut for better results. For all rates, except for age at first calving, the user can choose the animal category (age) to consider in the calculation. The available options in the app include 13-14-month-old heifers, 25-36-month-old heifers, cows above 36 months old, as well as a general calculation of the herd. This categorization enables the producer to identify which category needs better handling adjustments.

Application Development

During the development of this project, the Scrum methodology was adopted for management and planning of software projects. This agile methodology involves teams associated with specific roles, events, artifacts, and rules, where each component plays a distinct role (LEITE and LUCRÉDIO, 2014). The



development process was divided into Sprints, which are development cycles with a pre-established duration and defined goals to be achieved. At the end of each Sprint, the team held an alignment meeting.

For the development of the application, the Integrated Development Environment (IDE) used was Android Studio, provided by Google. The construction of the application was based on the works of Pooch *et al.* (2018). Android Studio (ANDROID DEVELOPERS, 2017) offers good support for specific plugins for the Flutter development framework, which was used to build the application. Besides providing great support for Flutter, Android Studio offers developers useful tools when working on code, such as syntax highlighting, version control tools, testing environment, and Android device emulator.

Flutter enables the creation of hybrid applications for both Android and iOS platforms using the same source code. The development of the graphical interface was based on Widgets, which are building blocks of the user interface. Flutter has an advantage over other mobile application development frameworks in that it does not use the widgets provided by the device's operating system. Instead, it has its own rendering engine, which enables it to design its own widgets (CORAZZA, 2018). Therefore, the application was developed using Dart programming language, and Material Design (GOOGLE DATABASE, 2017) was adopted as the design methodology.

Tests

During the development of the application, interface and functionality tests were conducted on both physical and virtual devices emulated by Android Studio, all of which were on the Android platform. This approach allowed for testing on a wide range of device models and operating system versions, enabling the team to identify and address potential failures during the use of the application.

Results and Discussion

As a result of this study, we developed a mobile application named BovCria, which is now available for free on the Android platform via the Google Play Store. The application is available in both English and Portuguese and provides tools for breeders, professionals, and agrarian science students to evaluate performance results and adopt management practices to improve the productivity and reproductive rates of beef cattle breeders. The application is designed to be fast and user-friendly. To install the application, please use the Google Play Store link provided at:

<https://play.google.com/store/apps/details?id=bovcria.ddpaseapi.rs.gov.br.bovcria>.

The productivity evaluation indices recommended in this application for the cow-calf system are widely used in the beef cattle industry. The application not only provides a quick and easy calculation of these rates but also encourages users to compare their herd's results with recommended goals outlined in specific performance tables. Additionally, the application offers management tips to help users achieve better productivity results.

The software's algorithm was developed based on the flowchart depicted in Figures 2, 3, 4, and 5. This flowchart outlines the sequence of activities involved in choosing the rate to be calculated, entering herd data,



processing (calculation), displaying the result, and providing access to comparative tables, management tips, and additional information. The application is comprised of three main screens: the start screen (Figure 2.A), which highlights the main objectives of the application; the content screen (Figure 2.B), which contains shortcuts to the main functions; and the information screen (Figure 2.C).

The application provides calculation of eight (8) predetermined rates and an index assessment for the user. These rates are designed to support farmers in measuring the productive and reproductive efficiency of their herds. To use this functionality, the user only needs to input numerical and classification parameters and submit them to the application. The application will then process the data and provide feedback to the farmer/user regarding the obtained rate. A practical example of how to use the application is presented in Figure 3.

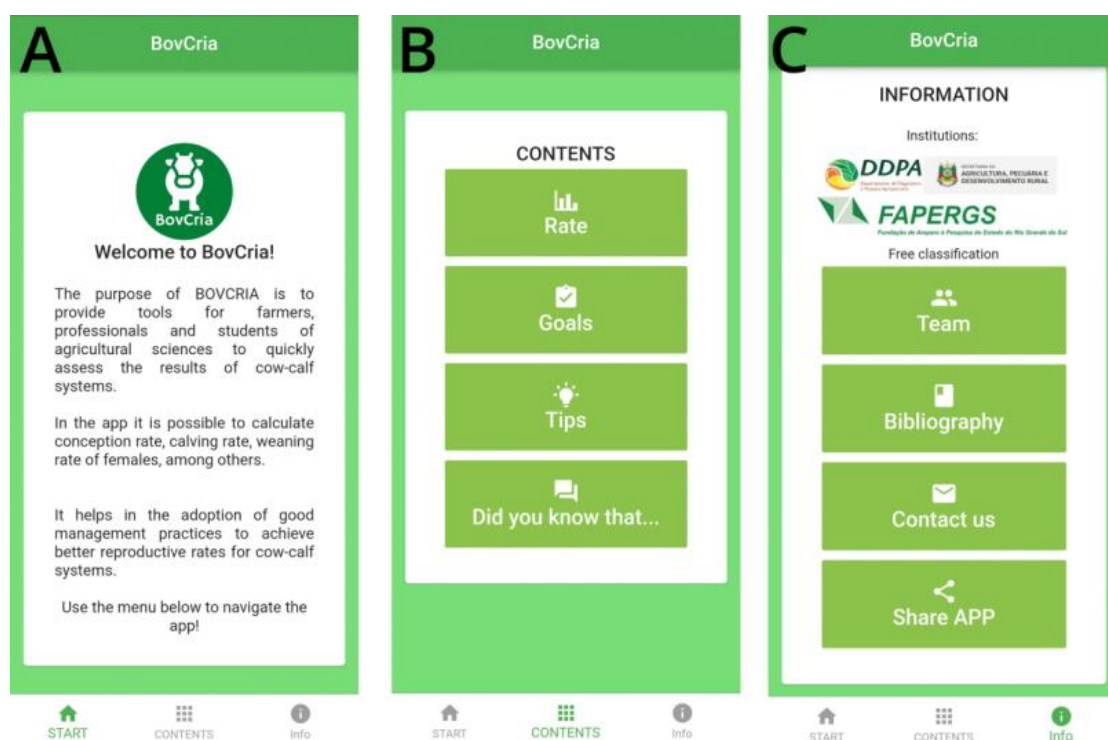


Figure 2. Three main screens are available in the application: the start screen, which presents the main objectives of the application (Figure 2.A); the screen that contains shortcuts to the main functions (Figure 2.B); and the information screen, which presents the credits to the development team (Figure 2.C).



Figure 3. The application simulates the calculation of rates for the user. The user selects the index to be calculated and the animal category, enters their herd data (highlighted in red), sends it to the application, and receives the calculated rate result (highlighted in black). The application also suggests support materials to assist the user.

Other available resources on BovCria

The application not only provides automated rate calculations but also offers support materials for consultation. These materials include management tips and herd goals, which can serve as a guide when used along with the appropriate rate results for the analysis of the user's interest. After each rate calculation, the user is directed to check the appropriate handling to improve their results. The user can access these resources either through the content menu present in the application (Figure 4) or through the suggestion of complementary material, generated after calculating the rates (Figure 5).

Validation Results Using Recorded Field Data

The developed tool was validated using data from a beef cattle herd at the Iwar Beckman Research Center, located in Hulha Negra – RS, Brazil, which is managed by the Department of Agricultural Diagnosis and Research (DDPA) of the Secretary of Agriculture, Livestock, and Rural Development of the State of Rio Grande do Sul (SEAPDR). The data collected corresponded to the breeding season of 2020 and 2021 and is presented in Tables 2 and 3.

No test was conducted to evaluate the user's experience with the application. However, user reviews can be checked through the Google Play Console platform. A user rating questionnaire will be included in the next update of the application. The application was launched in May 2020 and can be installed through the



available Google Play Store.

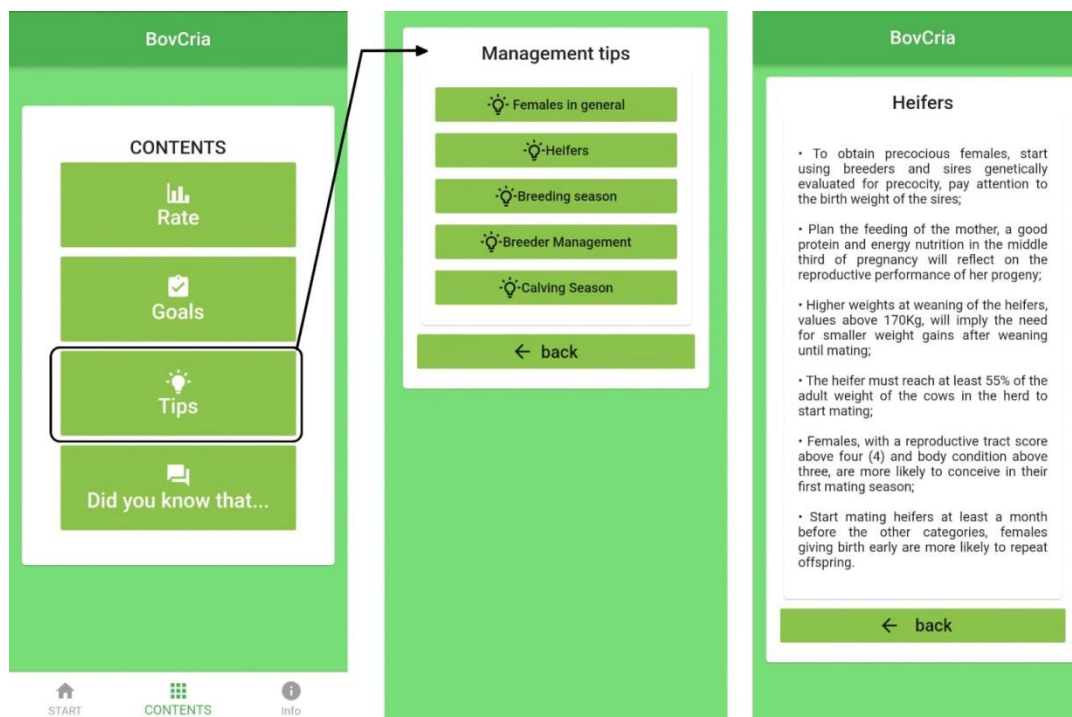


Figure 4. Access to query resources through the content menu. The user chooses one of the contents of interest, for example, heifer management tips, obtaining information to improve the results of the herd.

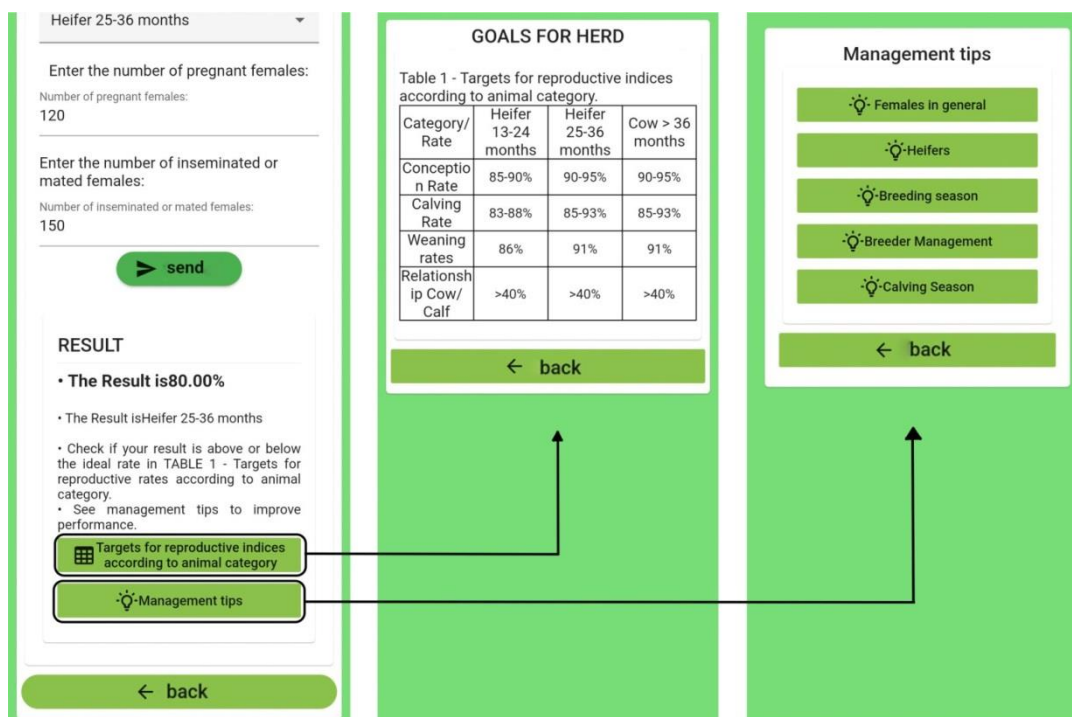


Figure 5. The user is encouraged to access the information resources suggested by the application after obtaining the calculated rate result, to compare it with the recommended targets, and to check management tips to improve results.

**Table 2.** Beef cattle herd data in the 2020/2021 breeding season (DDPA/SEAPDR).

Animal category	Number of head
13-14 month old heifer	30
25-36 month old heifer	50
Cow above 36 month old	120
Total number of females	200
Calf born (0-12 month old)	136
Calf weaned (> 7 month old)	128
Bull	8
Total animals beginning of the year	344
Number of dead calves until weaning	8
Number of other animals dead in the year	7
Total head of the end of the year	329

Table 3. Simulation results for reproductive efficiency indices calculated using field data from DDPA/SEAPDR Herd in BovCria application interface.

App features	Formula	Calculation (Herd data/App)	Results
Age at first calving (months)			
Enter average age of the herd	Not applicable	Not applicable	DDPA herd 36 App result Satisfactory age See guidelines in general herd indices and management tips
Interval between calving (days)			
Select the animal category	(Date of last calving) –	(08/23/2021)- (07/20/2020)	DDPA herd 399 App result Your result is 399 days Check if your result is above or below the ideal rate in Table 2
Enter the date of the last two calving	(previous calving date)		
Annual general mortality rate (%)			
Select General calculation	(N° of dead animals/total n° of animals in the herd)x100	(15/344)x100	DDPA herd 4.36 % App result The result is 4.36 % Check if your result is above or below the ideal rate in Table 2 See management tips to improve performance
Enter with herd data			
Annual mortality rate of calves until weaning (%)			
Select General calculation	[(N° of calves born - N° of calves weaned)/ (N° of calves born)]x100	[(136-128)/136]x 100	DDPA herd 5.88 % App result The result is 5.88 % Check if your result is above or below the ideal rate in Table 2 See management tips to improve performance
Enter with herd data			



Conception rate (%)				
Select animal category (general calculation or by category)	(N° of pregnant >36 month old cows/N° of >36 month old cow inseminated/mated) x 100	(100/120) x 100	DDPA herd	83.3 %
			App result	The result is 83.3 % The result is Cow > 36 month old Check if your result is above or below the ideal rate in Table 1 See management tips to improve performance
Calving rate (%)				
Select animal category (general calculation or by category)	(N° of calved cows/ N° of cows inseminated or mated) x 100	(136/145)x100	DDPA herd	93.79 %
			App result	The result is 93.79 % Selected category: General calculation Check if your result is above or below the ideal rate in Table 1 See management tips to improve performance
Weaning rate (%)				
Select animal category (general calculation or by category)	(N° of calves weaned/ N° of cows inseminated or mated) x 100	(128/145) x 100	DDPA herd	94.12 %
			App result	The result is 94.12 % Selected category: General calculation Check if your result is above or below the ideal rate in Table 1 See guidance on management tips and “did you know...” to improve performance
Ratio calf cow (%)				
Select animal category (General calculation or by category or individual calculation)	(Weight of the weaned calf in kg/ weight of dam in kg) x 100	(180/450) x 100	DDPA herd	40 %
			App result	The result is 40 % Selected category: General calculation Check if your result is above or below the ideal rate in Table 1 See management tips to improve performance
Actual production of kg of weaned calf/cow/year (kg)				
Select animal category (General calculation or by category or individual calculation)	(Weight of the weaned calf in kg x 365)/ interval between calving in days)	(180x365)/376	DDPA herd	174.7 kg
			App result	The result is 174.7 kg Selected category: Cow >36 month old Check if your result is above or below 170 kg If your result is below this value, see: Management tips



The user-friendly interface and interactive screens featuring goals, tips, and information make the application an educational and managerial environment for improving beef cattle herd productivity. The tables containing data on recommended goals and management tips for improving herd efficiency provide a fast and agile way to access this content. Furthermore, the application serves as a tool for popularizing science since much of this information is typically only available in scientific articles or printed materials that are not readily accessible to farmers in the field.

The development of mobile applications targeting the agricultural sector has become a reliable means of disseminating technologies and knowledge generated by educational and research institutions. BovCria is a mobile application that simplifies the calculation of the main indicators of reproductive and productive efficiency of breeding herds widely used in beef cattle production. Transferring data from the experimental farm to the digital environment has proven to be an efficient means of calculating indicators and evaluating herd performance. However, it is necessary to include a user opinion survey to assess the applicability of this mobile application on a larger scale. BovCria is a scientifically-based tool that facilitates beef cattle farmers in calculating rates, accessing recommended indexes for better results, and using them to evaluate their production. Its user-friendly interface and interactive screens make it an educational and productive management tool for beef cattle herds. The tables containing data on recommended goals and management tips for improving herd efficiency provide a fast and agile way to access such content and popularize scientific knowledge that is not always readily available to farmers in the field.

In a world increasingly connected, this tool replaces complicated tables or software and keeps important information in the palm of producers' hands. The expansion of internet access in rural areas allows for more efficient and agile methods to meet the demand for animal production. The use of the BovCria application allows producers to quickly evaluate the efficiency of their herds, aiding in making management decisions on farms.

Acknowledgments

The authors would like to thank the government of the State of Rio Grande do Sul, the National Council for Scientific and Technological Development (CNPQ), and the Fundação de Amparo à Pesquisa do Estado do Rio Grande do Sul (FAPERGS) for the Technological Initiation/Technological Development and Innovation Scholarships – PROBITI/FAPERGS/SEAPDR and PIBITI/CNPQ/SEAPDR.

Conflict of Interest

The authors declare that the research was conducted in the absence of any potential conflicts of interest.

Ethical Statements

The authors confirm that the ethical guidelines adopted by the journal were followed by this work, and all authors agree with the submission, content and transfer of the publication rights of the article to the journal. They also declare that the work has not been previously published nor is it being considered for publication in





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