A time-series analysis of Alpine and Saanen goat milk productivity trends in Taiwan

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Abstract

In order to project amounts and fluctuations in goat milk and milk components in Taiwan, it is necessary to analyze long-term animal data with multiple lactations. This study analyses the trend and seasonality of goat milk production and its components between 2018 and 2022. A total of 20,738 lactation records were collected from 2,376 Alpine goats and 522 Saanen goats from January 2018 to December 2022. In each record, the goat's lactation total milk, fat, and protein yields were calculated. Time series decomposition was used to determine milk productivity's trend and seasonal pattern. The results showed distinct trends and seasonality between goat breeds and lactation numbers. We observed similar seasonal and amplitude patterns across all lactations for fat, protein, and lactose yield, respectively. Higher lactation numbers also showed a larger seasonality amplitude for all yields (milk, fat, protein, and lactose). Additionally, different patterns were observed for all yields between Alpine and Saanen goats regardless of lactation. The results could be used for advising management decisions according to farm and breed productivity goals. In addition, trend and seasonal patterns can be utilized in Taiwan goat milk industry to forecast milk, milk component, and component production by specific breeds of goats.

Keywords: dairy goat, milk yield, time series analysis.

Introduction

Milk yield has a substantial impact on the economic profitability of dairy goat farms. Therefore a great deal of attention is paid to the analysis of this indicator as well as the factors which influence goat milk production. At farm level the milk production and milk components are influenced by factors which impact the whole goat herd but at the same time there are factors which affect individual animals. In order to make managerial decisions, it can be desirable to assess the yield of individual goats in the context of the herd at a concrete farm. The basis for yield evaluation is modelling of a 200-day lactation yield. Using a mathematical model for the description of the lactation curve leads to the need for finding a suitable regression function for fitting of measurements of daily yield, which are performed mostly only once a month. The Wood function is the most preferred method for solution of this nonlinear regression problem (Wood, 1967).

To evaluate phenomena observed in the long term, which have an individual impact and occur less frequently, it is desirable to standardize the estimated 200-day lactation yield. A timeline may be convenient to capture correctly trend, seasonal, and cyclic components. The existence of these components needs to be tested at a chosen level of significance with suitable statistical tests. Subsequently, the productivity can be stripped o substantial factors. The main goal of this study is to propose a suitable solution to the issue of yield correction in selected animals, which will make comparisons possible in the long term.

Material and methods

Animals and dataset

We used a dataset provided to us by the Taiwan Dairy Herd Improvement of Goat. The dataset included Holstein lactation records with following variables: milk yield (kg/goat for a whole lactation), fat percentage (%) and yield (kg/goat for a whole lactation), protein percentage and yield (kg/goat per lactation), lactose percentage and yield (kg/goat per lactation), lactation starting date, parity, location, and lactation length (d) across an 5-year period. A total of 20,738 lactation records were collected from 2,376 Alpine goats and 522 Saanen goats from January 2018 to December 2022. In each record, the goat's lactation total milk, fat, and protein yields were calculated.

Time-series data decomposition

The time-series milk production data were decomposed into trend, season, and error to facilitate separate examination for each of them. Additive time-series data consisted of trend, season, and irregular (error) components, and the model is given as follows:

$$y_t=T_t+S_t+I_t$$

where y_t is the milk production value at time t, T_t is the trend cycle component at time t, S_t is the seasonal component at time t, and I_t is the irregular (remainder) component at time t.

Results and discussion

Each decomposed time series contained monthly trend and seasonality components.

Milk yield per lactation

Upon decomposition of the actual data into trends, it was revealed that a consistently increasing trend in Alpine goat milk production could be observed over the period 2018–2019, and the milk production reached its plateau in 2020 and gradually decreased since 2021 (Figure 1). The Saanen goat milk also had similar increase over the period 2018–2019, but were slightly decrease to 700 kg per lactation and remained relatively steady since then (Figure 2). When the data was decomposed into a seasonal component, a seasonal pattern was clearly shown, with the predominant peak in milk production per lactation occurring in Alpine goat kidding in December and Saanen goat kidding between March and September.

The mean Alpine milk production of the present study 700 kg per lactation was inferior to the national average of French Alpine goat herds (949 kg/goat; IDELE, 2017), showing considerable potential for improvement of Taiwan dairy goat productivity. Multiple studies have reported the influence of month and season of kidding on peak milk yield, lactation persistence, and lactation milk yield of dairy goats (Montaldo *et al.,* 1997; León *et al.,* 2012). The higher milk yield in spring kidders was likely driven by the longer photoperiod during mid lactation, as December kidding would result in peak production in March when the photoperiod gradually increased, whereas November kidding would result in peak production in February when the photoperiod is reduced to nearly minimum. Goats that kidded in winter reached peak lactation earlier and slowly reduced daily yield in the subsequent months. Conversely, goats that kidded in early spring reached peak lactation much later.

For lactation milk yield, long term trends suggested a similar pattern between primiparous and multiparous Alpine goat. A plateau of 700 kg milk yield per lactation for multiparous Alpine goat was reached since mid 2019 to 2020, while the primiparous Alpine goat can only reached a trend of 650 kg per lactation (Figure 1B). The milk yield per lactation difference between primiparous and multiparous Saanen goat (650 kg vs 800 kg) was even larger than those in Alpine goat (Figure 2B). The seasonal components revealed that multiparous goat has different pattern and larger amplitude than those in primiparous goat.

Slightly distinct groups with closer long-term trend and seasonality patterns among lactations and locations. The improved classification of the original and the decomposition parameters can assist with herd and cow management decisions demonstrating the importance of seasonal patterns in production variables according to geographical location and parity.

Yield and content of fat, protein, and lactose per lactation

For fat, protein, and lactose yield, a consistently increasing trend in Alpine and Saanen goat milk could be observed over the period 2018–2020, when it reached its plateau in 2020 and gradually decreased since late 2021 (Figure 3-6). We observed similar seasonal and amplitude patterns across all lactations for fat, protein, and lactose yield, respectively. The overall trend for fat content is increasing since 2018, but protein, and lactose content were also increased since 2018 to 2019 and then and stabilized since then. Milk from spring kidders had a higher fat, protein, and lactose lactation yield than autumn kidders. Thus, this suggested that the decline in total milk solids yield during winter lactation was, to some extent, a synchronization effect of the decreased milk yield with decreasing photoperiod. There might be other environmental factors causing the seasonal variations such as feed and forage quality, air temperature, relative humidity, rainfall, and solar radiation, they have been suggested as significant effects on milk yield and milk physicochemical composition (Nardone *et al.,* 2010; Salari *et al.,* 2016; Clark and García, 2017).

Industry implications

Dairy goat farmers in Taiwan are aiming to continue increasing milk production over the next 5 year. Our results showed that month of kidding had a considerable effect on lactation curves of dairy goats in Taiwan, indicating that light manipulation, a cost-effective and straightforward method (Garcia- Hernandez *et al.,* 2007; Russo *et al.,* 2013), could accelerate increments in the national herd productivity. Moreover, this study has identified significant interactions between month of kidding and parity number, suggesting that the effects of such factors on milk traits are not independent of each other and that interactive effects should be considered when analyzing individual performance. From a higher-level perspective, most of these results are consistent with previous findings. However, this study not only gives additional information on how nongenetic and environmental factors can affect milk production of commercial dairy goats but, most importantly, also has produced new knowledge regarding productive traits of dairy goats raised in intensive feeding systems and managed in multiple kidding seasons per year.

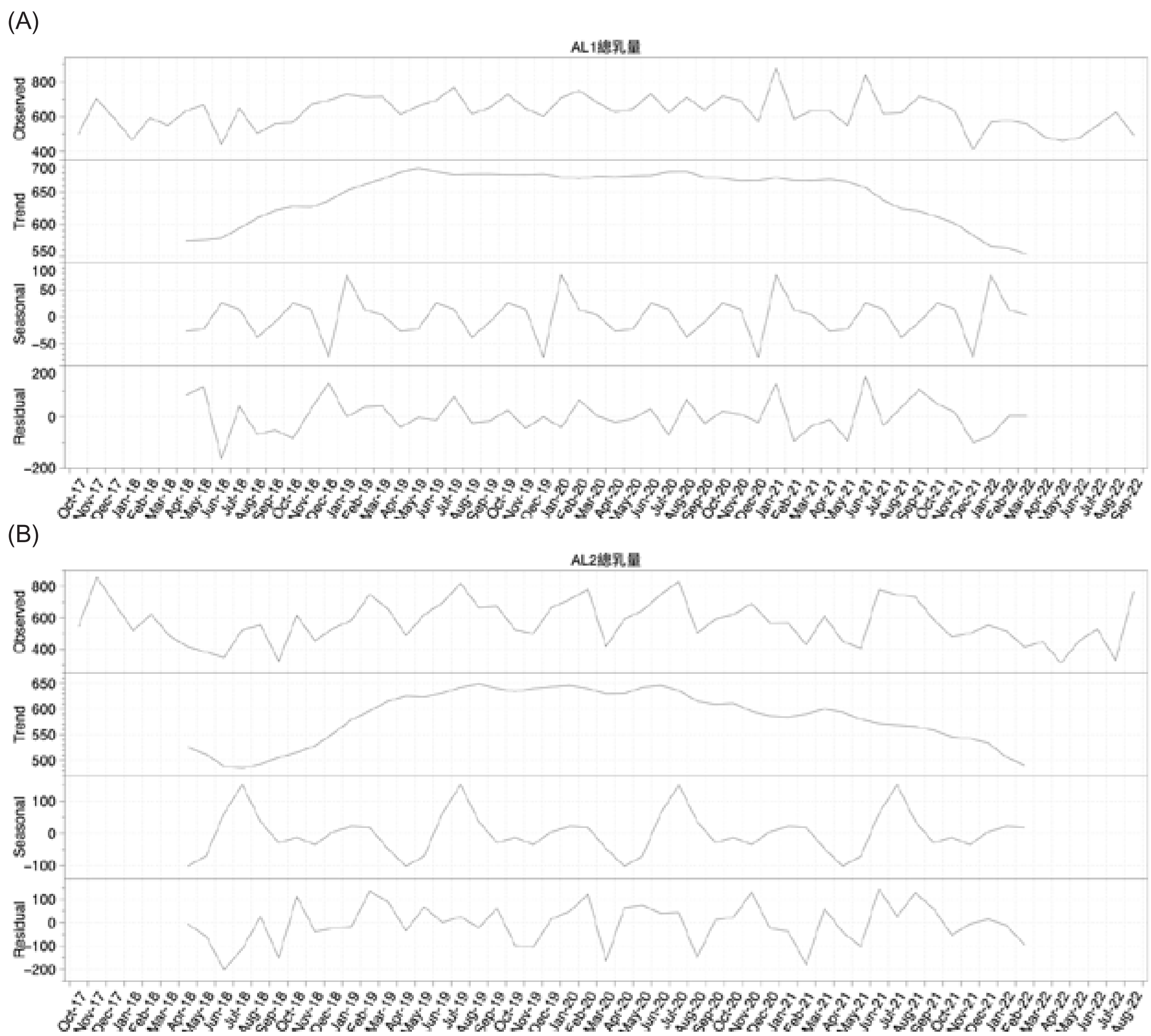

Figure 1. Time series decomposition of milk yield for (A) primiparous and (B) multiparous Alpine goat in Taiwan. Units are in kg/goat/year.

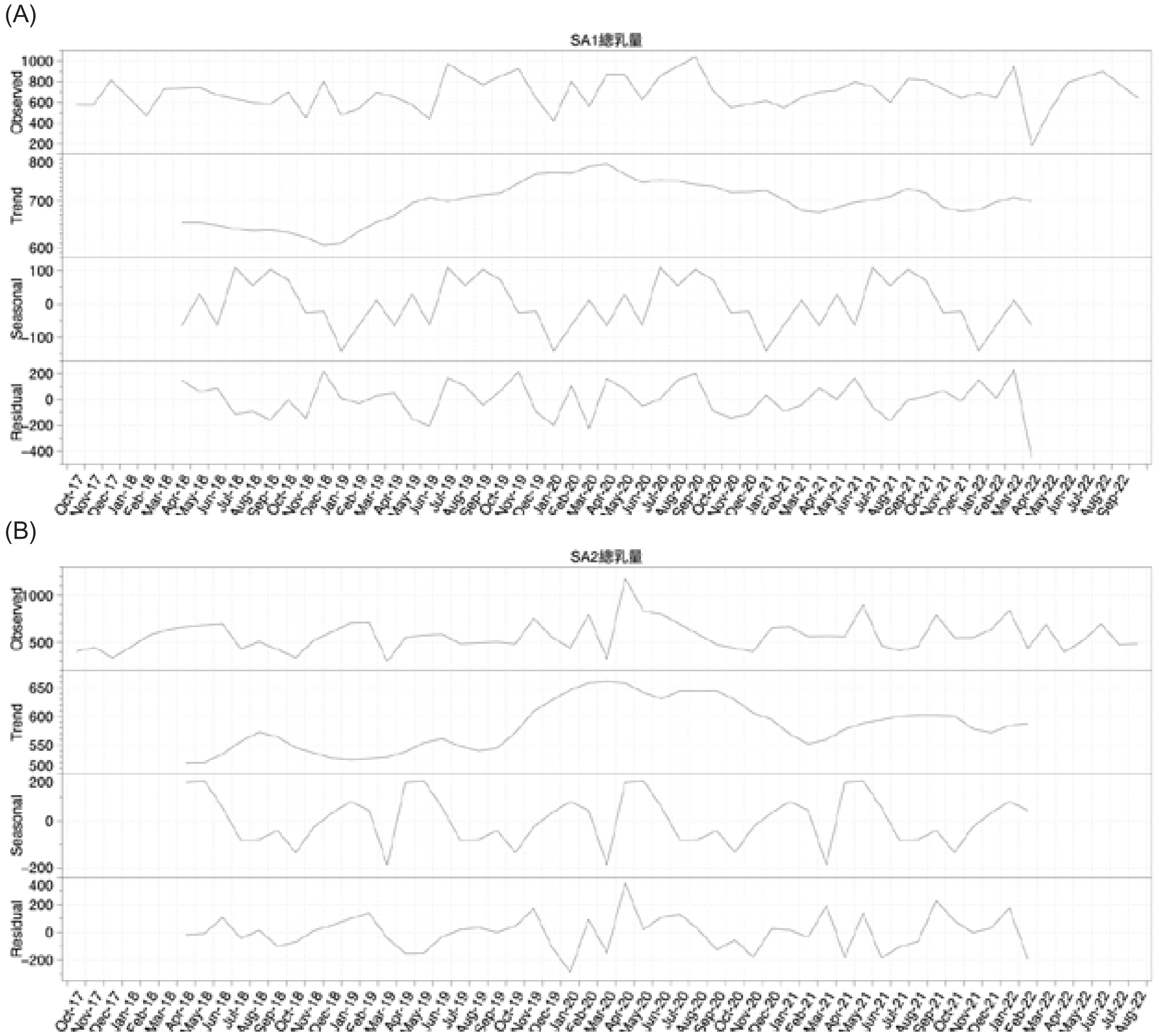

Figure 2. Time series decomposition of milk yield for (A) primiparous and (B) multiparous Saanen goat in Taiwan. Units are in kg/goat/year.

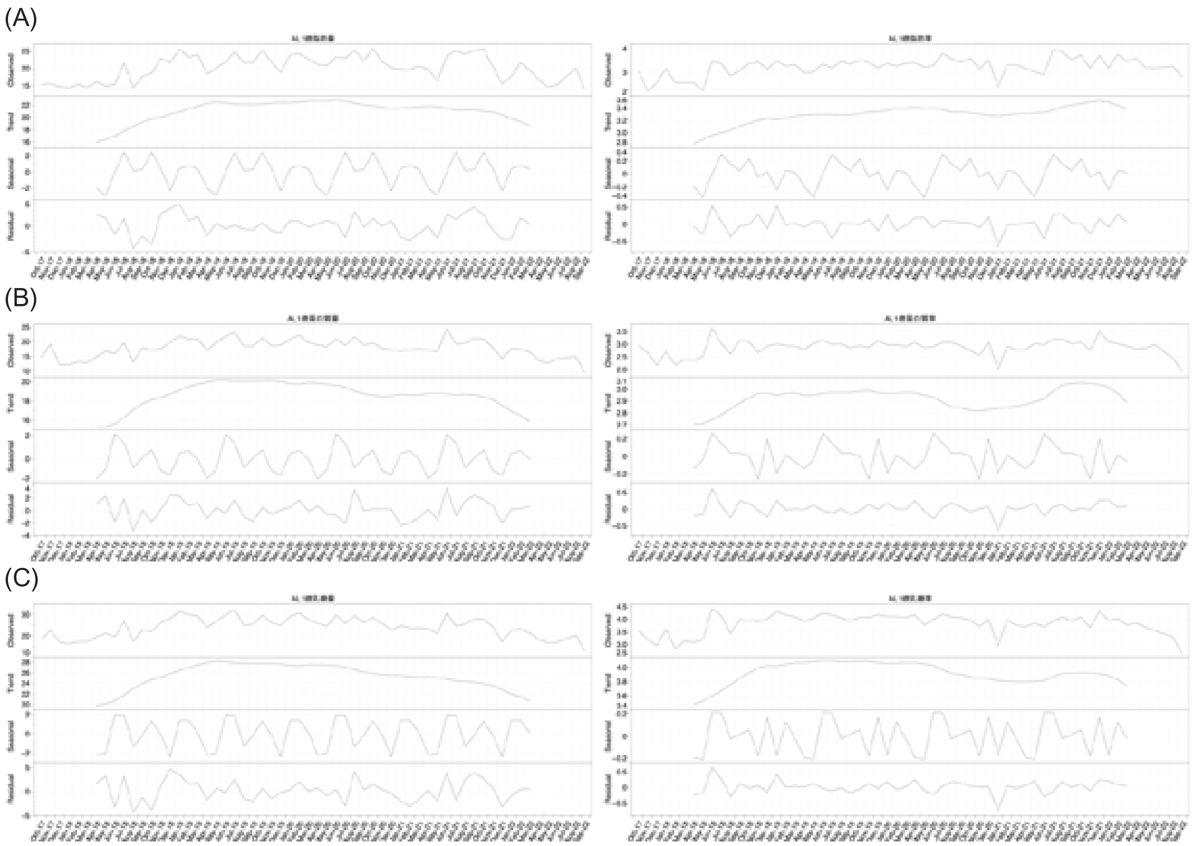

Figure 3. Time series decomposition of fat (A), protein (B), and lactose (C) yield (left) and concentration (right) for primiparous Alpine goat in Taiwan. Units are in kg/goat/year.

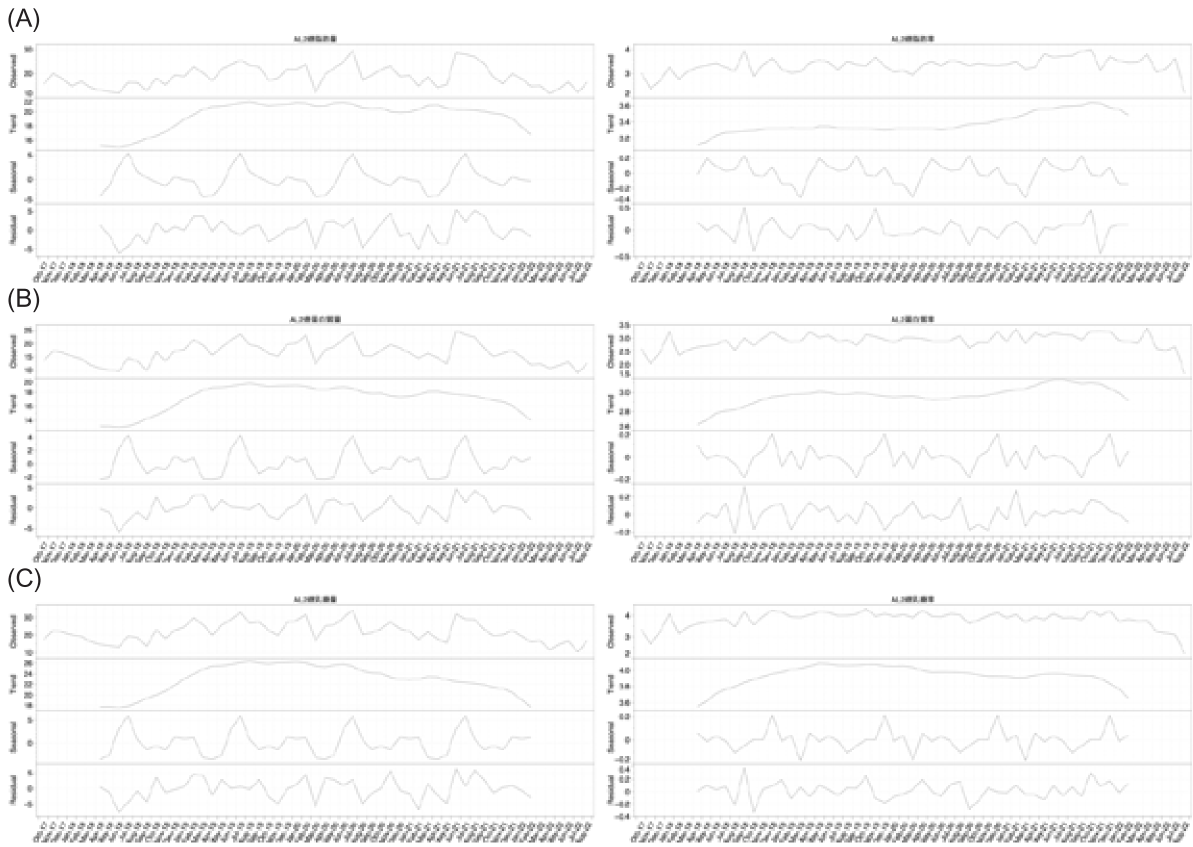

Figure 4. Time series decomposition of fat (A), protein (B), and lactose (C) yield (left) and concentration (right) for multiparous Alpine goat in Taiwan. Units are in kg/goat/year.

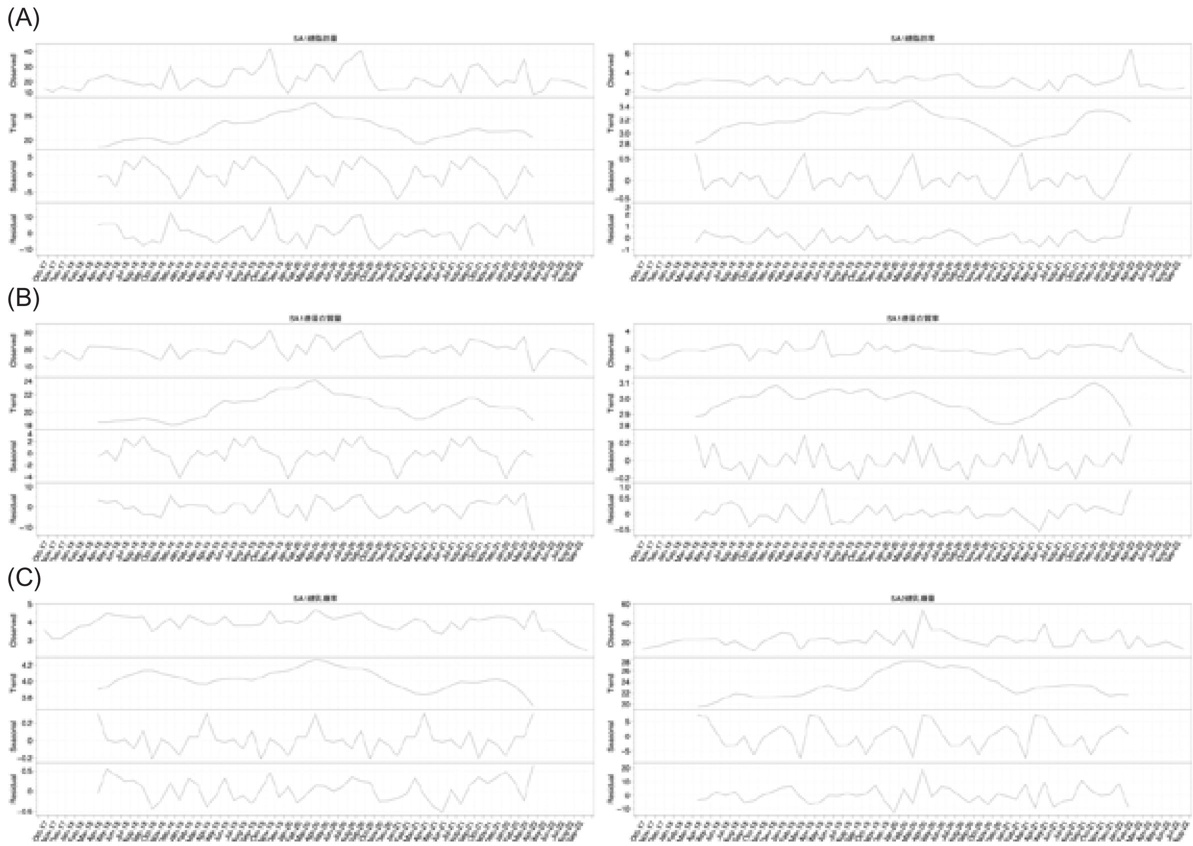

Figure 5. Time series decomposition of fat (A), protein (B), and lactose (C) yield (left) and concentration (right) for primiparous Saanen goat in Taiwan. Units are in kg/goat/year.

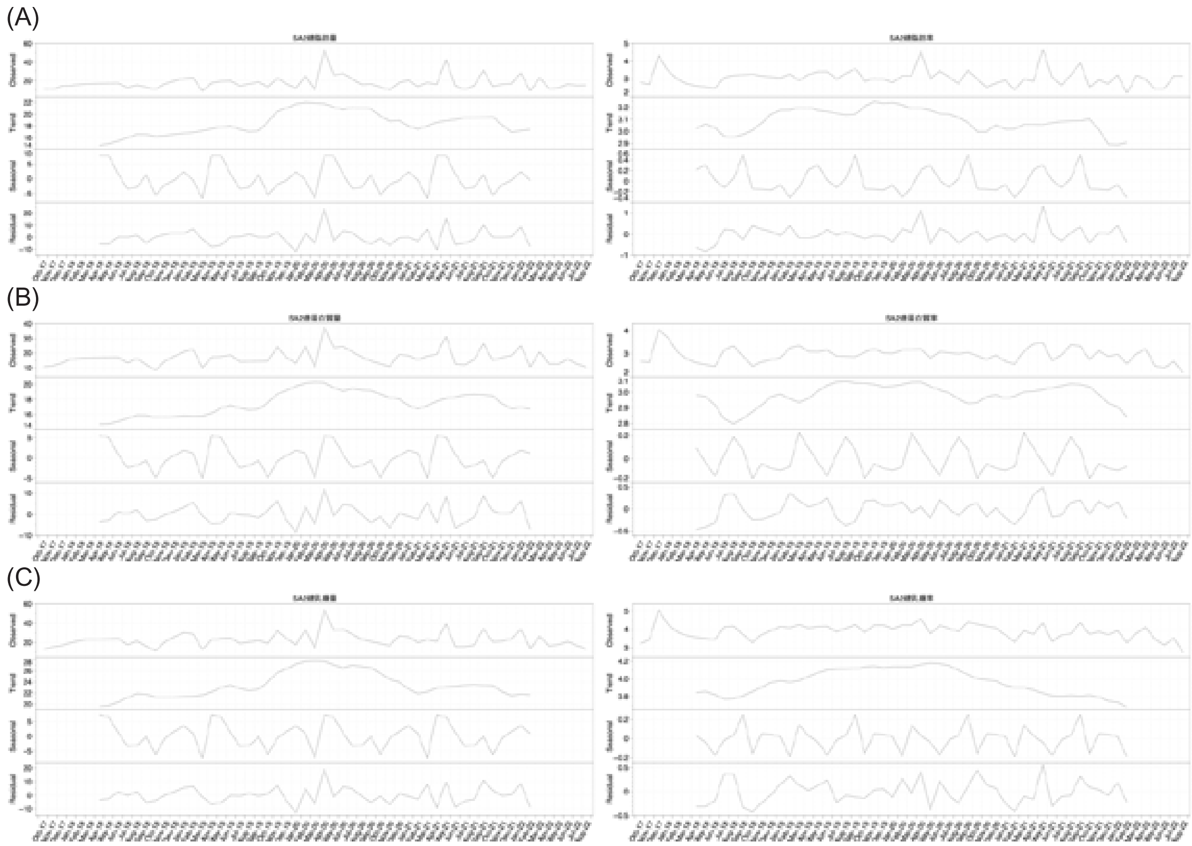

Figure 6. Time series decomposition of fat (A), protein (B), and lactose (C) yield (left) and concentration (right) for multiparous Saanen goat in Taiwan. Units are in kg/goat/year.

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