The development of a Windows based heifer growth and management decision support system

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Abstract Dairy managers are challenged to achieve heavier live weights and younger ages at first calving to increase profitability. The temporal dynamics of weaning, mating and calving in relationship to the supply of feed and live weight are critical decisions that need to be addressed. The dairy manager has to manipulate feed required and the feed available to achieve optimal dairy heifer growth. At present, the tools to help dairy managers to improve their management of dairy heifer growth and management are limited. Therefore *Higro*, a decision support system (DSS) has been developed to assist dairy managers improve the growth and management of dairy heifers. There are three distinct growth phases in managing heifers: weaning to twelve months of age, twelve months of age to mating and mating to calving. Each growth phase utilises a heifer growth module based on equations from the literature to determine how much metabolisable energy (ME (MJ)), crude protein (g), calcium (g), phosphorous (g) and their expected intake (kg dry matter (DM)). To achieve a particular target within a growth phase, a feeds database is linked to the growth module. After calculating the feed requirements, total feed supplied and surplus/deficit, a reports module is utilised to view the output before printing. This decision support system allows the user to conduct various weight for age and feeding scenarios to help balance feed resources and improve dairy heifer growth and management. This paper describes the use of DELPHI™, a Windows application development package to develop a heifer growth and management DSS.

1. INTRODUCTION

The growth and management of dairy heifers to achieve heavier liveweights (>550kg) and younger ages (<26 months) at first calving is often sacrificed for the management of the milking herd. Benefits from achieving heavier liveweights and younger ages at first calving include less heifers to rear, improved mating weights, lower incidence of dystocia (calving difficulties) and greater production per day of herd life (Hoffman and Funk 1992). Decision support systems (DSS) can assist dairy managers to improve heifer management strategies and achieve the benefits mentioned above. *Higro*, a DSS for heifer growth and management, is part of NSW Agriculture's package of extension tools to educate dairy managers in how to improve heifer growth and management.

CamDairy (Hulme *et al.* 1986), CamBeef (Irwin and Kellaway 1993), GrazFeed (1993), RumNut (AFRC 1993), and Cornell Net Carbohydrate and Protein System (Barry *et al.* 1994) are currently available to assist dairy managers improve the growth and management of their heifers. Some explore complex aspects of feeding (e.g. metabolisable protein requirements) while the majority address growth and management tactics. *Higro* differs from these other DSS by the way it allows the user to assess heifer growth and management in three distinct growth phases: weaning to twelve months of age, twelve months of age to mating and mating to calving. Each growth phase is divided into developmental periods where each period can be dealt with individually or as part of an overall management strategy.

The development of *Higro* has been achieved using Delphi™ version 1.0. This Windows based application package was chosen for the following reasons: no run time costs, access to database tools, Pascal programming language, good reporting facilities (Report Smith™), visual and object-oriented programming features, friendly development environment, and reusable component-based architecture. The following sections describe the development of *Higro*.

2. PROGRAMMING FRAMEWORK

The Delphi programming framework makes the development environment friendly and easy to use owing to the use of reusable component-based architecture. Components are either selected or dragged and dropped onto forms where they have an associated range of properties and events (Figure 1). "Properties" cover a wide range of options associated with its component (e.g. changes the colour or font size). "Events" allow the developer to write code associated with an event (e.g. activating the form or clicking the component to perform tasks).

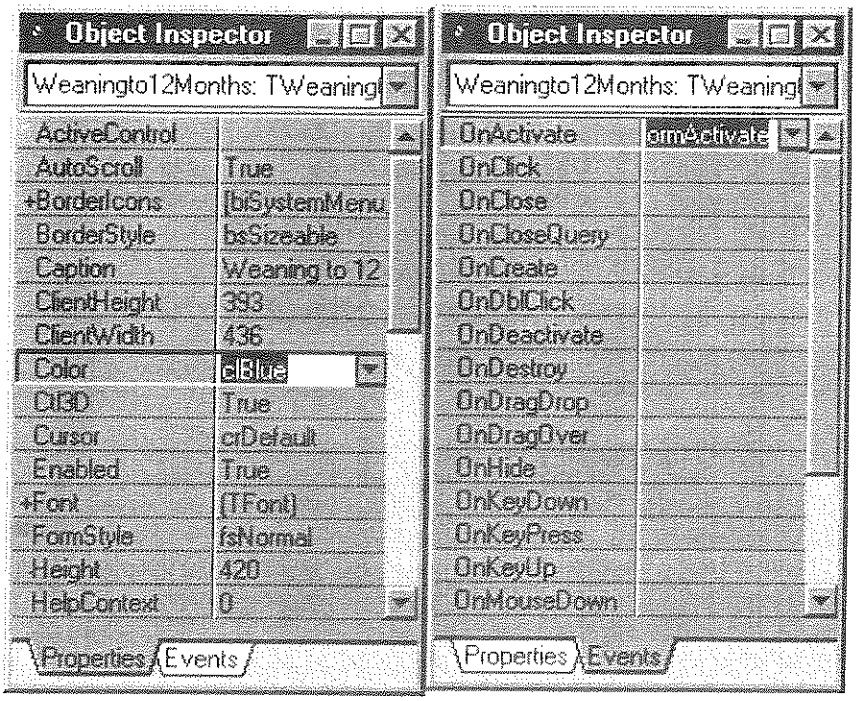

Figure 1: Object Inspector's properties and events for a form.

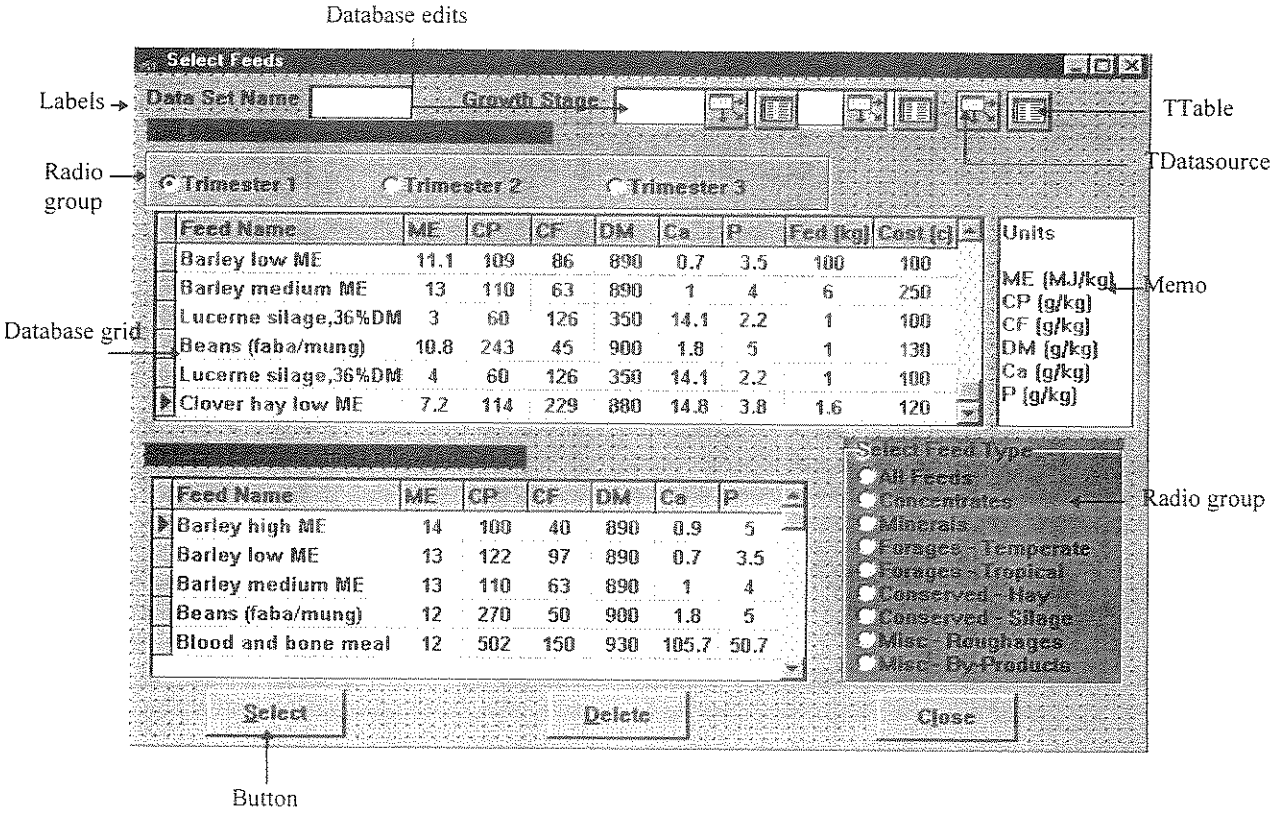

Figure 2: Select Feeds form with tables, data sources, labels, edits, radio groups, data base grids, memo and three button selections.

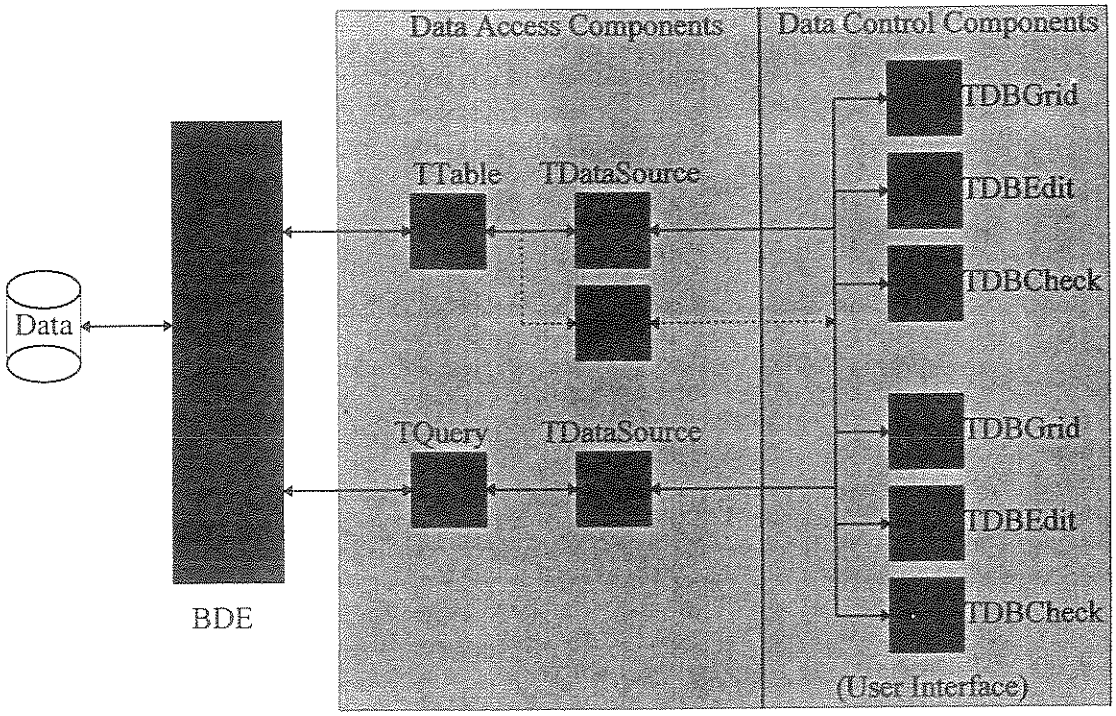

Figure 3: Data access and control components architecture.

The six forms in *Higro* are: main, weaning to twelve months, twelve months to mating, mating to calving, select feed and edit feed list. The forms use some of the following components: menu creators, printer dialogues, tables, data sources, labels, database edits, database look up combinations, database radio groups, database grids, and memos. Figure 2 displays the select feeds form with a range of components.

The unique features of tables and data source components allow the developer to link databases to the application. The linkages of data to the application via the Borland Database Engine (BDE), Data Access and Control Components are illustrated in Figure 3 (Database Application Developer's Guide 1995).

The TDataSource is linked to a dataset (TTable or TQuery). TTable and TQuery are similar except TQuery provides additional capabilities, e.g. multi-table queries (joins), and operations that require explicit SQL syntax. TTable is often sufficient in providing portable database access through the BDE.

Delphi also has a database desktop that provides an easy way to create and restructure tables. The database desktop supports indexing and SQL scripts. *Higro's* database structure comprises a main database incorporating the three growth stages, a main feeds database, a feeds offered database and three databases for the storage and retrieval of results.

3. DECISION SUPPORT SYSTEM FRAMEWORK

The framework of *Higro* is structured to calculate the daily heifer requirements (metabolisable energy etc) and their expected feed intake by utilising equations from NRC [1989] and Fox *et al.* [1992]. The necessary user inputs to calculate these requirements are breed size small (Jersey), medium, large (Holstein-Friesian), live weight and age targets. The feed resources are selected by the user from a feeds database where the inputs are the amount fed (kg DM/day) and cost (cents/kg). The difference between feeds supplied and requirements are then calculated for inspection in a nutrition report.

4. LINKING THE DSS FRAMEWORK

The linkage of the DSS framework within Delphi was not an arduous task. Delphi eliminates some of the tedious steps involved in application development. Match and Faulkner [1995] confirm that Delphi makes developing robust Windows applications a rapid and enjoyable process. There are four reasons why linking the DSS framework was successfully accomplished.

The first is the use of datasets (TTable and TQuery) and TDataSource components. As mentioned above, they are important tools for linking databases within Delphi. The dataset components give the developer access to database commands such as insert, append, edit or delete records.

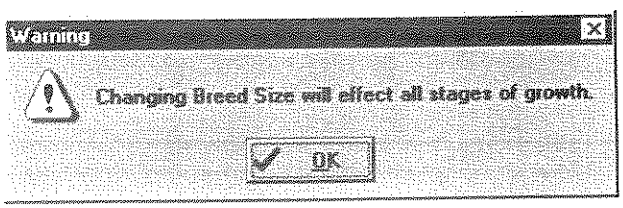

Figure 4: Warning dialogue box.

The following example illustrates SQL accessed through the TQuery component that creates the ration report.

```
SELECT

"FEEDRES"."DATASET", "FEEDRES"."AGE",
"FEEDRES"."NAME", "FEEDRES"."ME",
"FEEDRES"."CP","FEEDRES"."CA","FEEDRES"."P",
"FEEDRES"."AMT","FEEDRES"."COST"
FROM
\WINHIGRO\"FEEDRES"
ORDER BY
"FEEDRES"."AGE","FEEDRES"."NAME"
```

The second reason is the use of ReportSmith, a report generator for the Delphi environment. It enables the user to create reports without any knowledge of SQL and uses "live data" (Creating Reports, 1995). This powerful visual database reporting and query tool was used to create three reports in *Higro*: input, ration and nutrition. These three reports can either be viewed or printed. This report generator again reduced the programming time by eliminating the task of formatting output.

The third reason is the use of dialogue boxes for input, information, confirmation and warnings. Figure 4 is an example of a warning if the user changes the breed size.

The fourth reason is the use of radio groups. Radio groups and Pascal case statements assist in selecting criteria. The following example uses the radio group displayed in Figure 2 to select the type of feed and the application of the case statement. This code also illustrates the use of range statements to search within a database via the TTable component.

```
case FeedTypeRG.ItemIndex of
  0 : FeedType:=''; {All Feeds}
  1 : FeedType:='C'; {Concentrate}
  2 : FeedType:='M'; {Minerals}
  3 : FeedType:='FTE'; {Forages-Temperate}
  4 : FeedType:='FTR'; {Forages-Tropical}
  5 : FeedType:='CH'; {Conserved-Hay}
  6 : FeedType:='CS'; {Conserved-Silage}
  7 : FeedType:='MR'; {Miscellaneous-Roughage's}
  8 : FeedType:='MB'; {Miscellaneous-By-Products}
end;
if FeedTypeRG.ItemIndex <> 0 then
be.g.in
  FeedList.DisableControls;
  try
    FeedList.SetRangeStart;
    FeedListTYPE.AsString:= FeedType;
    FeedList.KeyExclusive:= False;

    FeedList.SetRangeEnd;
    FeedListTYPE.AsString:= FeedType;
    FeedList.KeyExclusive:= False;

    FeedList.ApplyRange;
  finally
  FeedList.EnableControls;
  end; {try}
end
else
  FeedList.CancelRange;
```

	Nutrient				
Growth Stage	ME	CP	Ca	P	Intake
Weaning to 6 months					
Requirements	39.7	583.6	19.1	11.6	3.7
Supply	52.4	844.5	29.9	30.7	4.6
Surplus/Deficit	12.7	260.9	10.8	19.1	0.9
6 to 9 months					
Requirements	50.1	660.3	21.3	14.6	4.7
Supply	108.6	1722.0	45.3	47.0	10.3
Surplus/Deficit	58.6	1061.7	24.0	32.4	5.6
9 to 12 months					
Requirements	66.1	780.3	24.1	17.9	6.5
Supply	76.8	890.0	43.0	15.0	7.0
Surplus/Deficit	10.7	109.7	18.9	-2.9	0.5

Table 1. The daily feed requirements, supply and surplus/deficit details of metabolisable energy (ME (MJ)), crude protein (CP(g)), calcium (Ca(g)), phosphorous (P(g)) and intake (kg dry matter(DM)).

5. CASE STUDY

The following case study illustrates the use of *Higro*. The data is from a dairy manager on the North Coast of NSW who is targeting a live weight of 280 kg at twelve months of age after weaning at three months of age at 90 kg live weight. The feeds available are a calf mix, ryegrass/clover hay, barley of medium ME, Rhodes grass (early vegetative), Kikuyu pasture (early vegetative) and molasses. The developmental periods within this growth phase are divided into three periods. Based on the target age and live weight inputs, *Higro* calculates the heifer's daily requirements, the total daily feed supplied and the difference between supply and requirements. By inspecting the three reports, the user can decide if the targets will be met with the available feeds. A summary of the *Higro* results for this study are shown in Table 1.

Table 1 indicates that in each of the growth stages, there is an over supply of nutrients except for phosphorous in the 9 to 12 months growth stage. This is acceptable and in the six to nine months period the over supply will increase the growth rate.

6. CONCLUSIONS AND FUTURE DEVELOPMENT

The future development of *Higro* will be enhanced by moving from the 16 bit application, Delphi version 1.0, to Delphi 3, a 32 bit application. Delphi 3 will provide the developer with a set of decision support components. In particular, the facility to graph and tabulate data with relative ease.

In addition to graphical displays, optimising the quantity and cost of feed supplied will improve the decision making process of the DSS. A first lactation prediction module to enhance the benefits of improving heifer growth and management will also be a worthwhile future development.

This paper has described the development of *Higro* using Delphi, a Windows application package. The use of component based architecture and ReportSmith assisted in the rapid development of this DSS. The linkages between components, Pascal code and databases are a strength of the Delphi environment. ReportSmith was excellent in generating easy reports but formats different from any of the standard forms proved to be a challenge. ReportSmith also tended to be memory hungry. The case study highlights that *Higro* has a role to play in the temporal dynamics for weaning, mating and calving. The methodology of breaking the growth from weaning to calving into phases and developmental periods is a simple but vital step towards improving management of the feed supply to achieve optimal dairy growth.

7. ACKNOWLEDGMENTS

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