AMNOS: AN INTEGRATED WEB-BASED PLATFORM FOR DAIRY SHEEP BREEDING MANAGEMENT

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INTRODUCTION
A successful program for the genetic improvement of dairy sheep depends on a) reliable recording of milk and other economically important traits, b) appropriate data analysis and genetic evaluation to identify superior breeding animals, and c) development of genetic resource management and mating strategies. Information Technology has been used to effectively integrate these procedures (e.g. Gootwine et al., 1994).

The objective of this paper is to describe AMNOS, an integrated web-based platform, developed to record, monitor, evaluate and manage the dairy sheep population of the Chios breed in Greece. The operating environment of AMNOS is illustrated in Figure 1. Three main categories of users may input data into the AMNOS database through the web: a) the sheep owners, b) the inspectors, and c) the inseminators. AMNOS analyzes the stored data and returns valuable feedback to the owners.

Figure 1. Information flow and user categories in the AMNOS platform
DESIGN
The key component of the platform is a database with the following relations operating at the flock and individual animal level:

**Flock level**
1. **Owner relation**: includes information on the flock owner (name, contact details, age).
2. **Inspectors relation**: includes information on the officers delivering milk recording and animal identification services to the flock.
3. **Inseminators relation**: includes information on officers administering Artificial Insemination services to the flock.
4. **Recording Information relation**: includes total milk production of the flock, date and time of milk recording, and number of milkings.

**Individual animal level**
5. **Registration relation**: includes animal pedigree and status.
6. **Animal Information relation**: includes additional animal information (e.g. picture, special characteristics and marks).
7. **Lambing relation**: includes lambing information and prolificacy records.
8. **Lamb relation**: includes lamb identification, lamb status and various weight records.
9. **Test-Date relation**: includes milk yield and milk component record on date of test.
10. **Milk Calculation relation**: includes calculated lactation milk production.
11. **Genetic Evaluation relation**: includes estimated breeding value of the animal.
12. **Matings relation**: includes date and type of mating and sire/dam identification.

The database structure and links among the above relations are illustrated in Figure 2.

Figure 2. Database structure in the AMNOS platform

**Numbering system.** The procedure developed relies on the fact that animals will always be uniquely identified in the unit (e.g. flock) where the record is made (Groeneveld and Gutzmann, 1990). A cross-reference list was developed to convert the animal’s flock number to a unique, internal database number with which the animal may be identified anywhere in the database. Internal database numbers are consecutive and increase by one when a new animal enters the database.

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Business logic. A series of conventions and rules have been added to ensure data integrity. These rules are implemented as assertions and constraints on the database. Typical examples include:
1. The biological limits of traits recorded (e.g. milk yield between 200 g and 4 kg per test).
2. Checks on consistency of dates of recording (e.g. 1st test date to follow lambing date).
3. Completeness checks on reporting of insemination, lambing, and type of lambs born.

WEB design. The AMNOS database was created in the Microsoft SQL Server 2000 (Otey and Conte, 2000). Dynamic web pages are generated using the Microsoft ActiveX Data Object (ADO) technology in order to connect to the SQL Server database. Business logic was implemented on Active Server Pages (ASP), which were also responsible for creating the HTML pages sent to the user’s browser. While ASP performed the server side scripting, JavaScript was used for the client side scripting. The use of on-the-fly JavaScript checks, in combination with the standard HTML forms, frames and mixture of text and images, helped us create a user-friendly environment that minimizes the possibility of the user making mistakes while inserting or updating data. The different layers and methods used in the implementation of AMNOS are illustrated in Figure 3.

User roles. The following user roles have been created with the corresponding database privileges:
1. Administrator, responsible for the overall operation of the system.
2. Owner, responsible for input to Lambing, Lamb and Mating (for natural service) relations; has access to own flock and individual animal relations.
3. Inspector, responsible for input to Test_Date, Registration and Animal_Information.
4. Analyst, responsible for input to Test_Date, Milk_Calculation and Genetic_Evaluation.
5. Inseminator, responsible for input to Mating (for artificial insemination) relation.
**Reporting procedures.** The system design gave particular emphasis to presentation of results to farmers. An effort was made to minimize the number of displays while increasing their functionality. A total of 5 displays were developed, based on On-Line Analytical Process (OLAP) techniques and the use of Microsoft Analysis Services.

**USE**

Currently, AMNOS runs on a Windows 2000 server. A key advantage of Internet applications is that they can be accessed by anyone with a browser client. With very little or no additional development effort, an application can be accessed simultaneously from Microsoft Windows operating system, Apple Macintosh, OS/2 and UNIX clients. Standard Web browsers meet all client functionality demands.

Ease of management is another advantage of Internet applications. A Web server update automatically updates all clients. Furthermore, managing a Web page code with few servers is easier than managing other applications with many servers.

The system described here is administered by the Chios Sheep Breeders Cooperative “Macedonia” and the Center for the Genetic Improvement of Animals in Thessaloniki, Greece. Currently, the population monitored by the system is approximately 10,000 animals. User (sheep producer) participation in this new technology is being encouraged, to test the application and ensure long-term functionality. Costs for the users, however, may be sizeable (though not prohibitive), since this application requires subscription to an Internet provider (approximately 14 €/month) in addition to telephone costs for modem connection (approximately 0,003 €/min).

**FUTURE DEVELOPMENT**

Work is currently underway to complete the Genetic_Evaluation relation, develop the platform for mating strategies and organize marketing of genetic material. Genetic evaluations will be based on animal pedigree and test day records of milk and milk components. Estimated breeding values will be made available at the Genetic_Evaluation relation and can be accessed by any user with an Internet connection. Mating strategies will focus on avoiding inbreeding and maximizing genetic and economic gain.

**REFERENCES**

