

Laboratory Animal Management Assistant (LAMA): a LIMS for active research colonies

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Abstract Laboratory Animal Management Assistant (LAMA) is an internet-based system for tracking large laboratory mouse colonies. It has a user-friendly interface with powerful search capabilities that ease day-to-day tasks such as tracking breeding cages and weaning litters. LAMA was originally developed to manage hundreds of new mouse strains generated by a large functional genomics program, the Pleiades Promoter Project (<http://www.pleiades.org>). The software system has proven to be highly flexible, suitable for diverse management approaches to mouse colonies. It allows custom tagging and grouping of animals, simplifying project-specific handling and access to data. Finally, LAMA was developed in close collaboration with mouse technicians to ease the transition from paper- or Excel-based management systems to computerized tracking, allowing data export in a popular spreadsheet format and automatic printing of cage cards. LAMA is an open-access software tool, freely available to the research community at <http://launchpad.net/mousedb>.

Introduction

Genetic analyses using mice as a model system for human disease are a cornerstone of biomedical research. The history of mouse genetics is reflected in the early adoption of software for the management and analysis of mouse colonies (Bishop and Hanna 1968). Over four decades of applied animal colony informatics, researchers have progressively developed more flexible computational frameworks, including the adoption of database systems and the implementation of software using object-oriented programming languages (Boulukos and Pognonec 2001; Ching et al. 2006; Hopley and Zimmer 2001; Maier et al. 2008; McKie and Webb 1999; Montoliu 2003; Pargent et al. 2000; Silver 1993). The broad impact of any specific software system, however, has been negligible. It is our perception that none of the systems has been sufficiently flexible to serve a substantial portion of the research community. There are nearly as many approaches to animal husbandry as there are research facilities; every center appears to have implemented a unique set of procedures for the care and analysis of laboratory animals. The relative merits, benefits, and limitations of the approaches are not at issue. However, the diversity demands great flexibility in any informatics implementation for data management.

For researchers facing the choice between retaining a paper- or spreadsheet-based system and shifting to a laboratory information management system (LIMS), the balance is rapidly shifting from the tried-and-true to address the growing need for greater efficiency. The decreasing cost of screening procedures, the increasing access to robotics, and the broad availability of strains are placing an increased burden on the management of colonies (hereafter this report focuses specifically on mouse colonies). Modern wireless technologies are affordable, enabling animal care

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staff to work with convenient scanning devices facilitating increased colony size. In our eyes, the main impediment to the transition to LIMS in a mouse colony is the availability of suitable and user-friendly software systems and interfaces.

In this report we introduce the Laboratory Animal Management Assistant (LAMA), efficient LIMS software that can effectively track and manage large colonies of thousands of animals and hundreds of thousands of historical records from laboratory animal facilities. LAMA has been implemented for a broad community of users, allowing individual research labs to track independently their own colonies within a larger facility. The well laid out and intuitive user interface that is accessed via standard web browsers requires little staff training. The system features powerful search capabilities and flexible settings of user privileges. The software is open-access and available to the research community.

Materials and methods

The mouse attributes tracked in the initial release of LAMA include sex, date of birth, wean and death, strain, genotype, generation, parents, cage transfer history, and protocol.

The database schema is organized around core tables that capture essential data: mice, litters, strains, cages, mouse transfer history, and protocols (Fig. 1). It is supplemented with information needed for system operation: user accounts, permissions, user-indicated preferences, saved searches, comments, and tags. The core tables are designed to allow for easy extension to additional types of information in future iterations of the software.

The browser-based interface is implemented in PHP with Zend Framework (<http://framework.zend.com>), using a Model-View-Controller (MVC) design approach. The system makes extensive use of Ajax and incorporates the

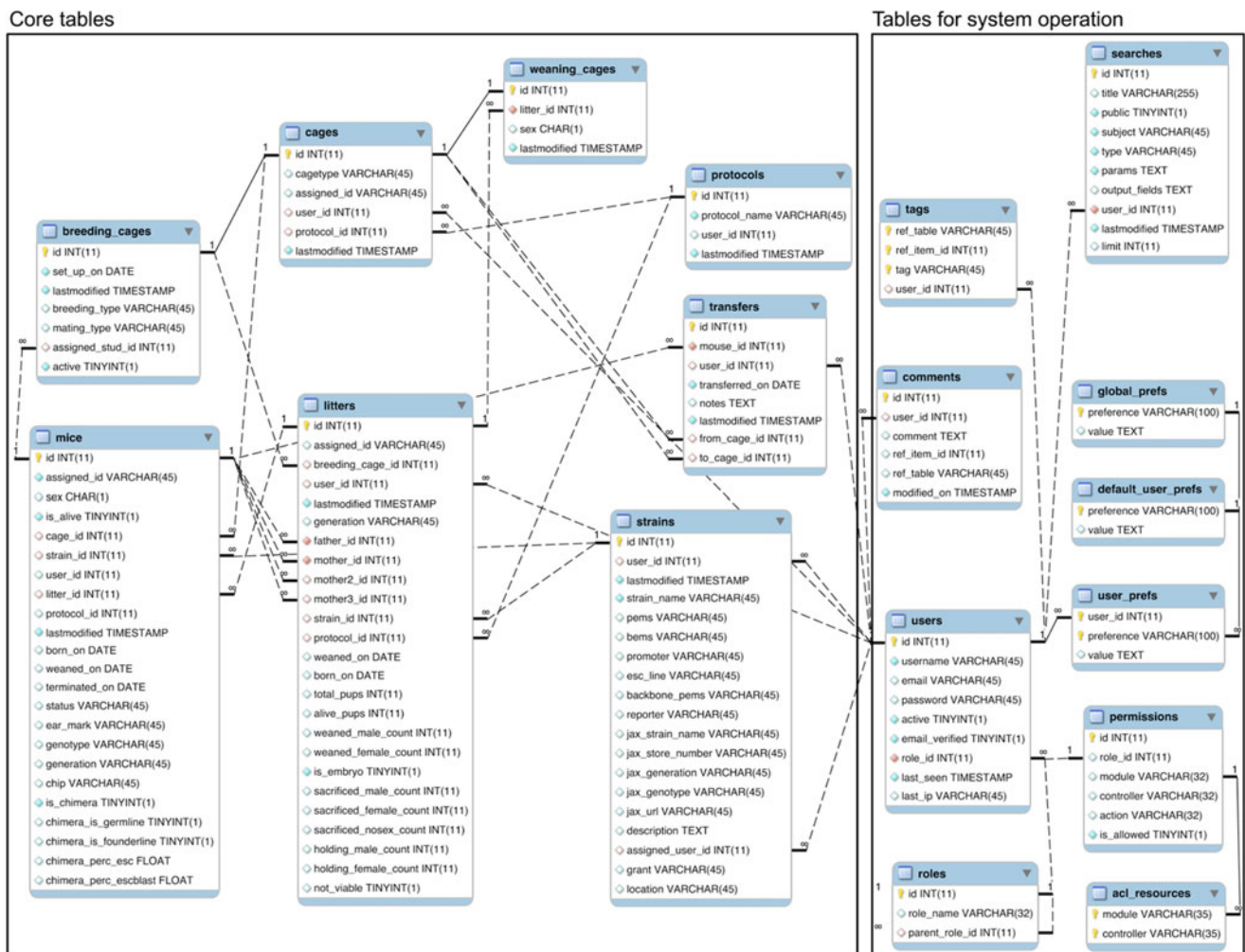


Fig. 1 LAMA database schema. LAMA presents a simple and flexible database schema revolving around core tables holding the mouse information and additional tables used for system operations

Dojo Toolkit (<http://www.dojotoolkit.org>) to enhance interface responsiveness by populating drop-down lists after page load and by using partial rendering to replace page sections in response to user interaction.

The system allows creation of arbitrary groupings or associations between records in the database by use of tagging. One or more tags or keywords can be assigned to records in all core tables. All items tagged with a given keyword can be displayed, providing for simplified overview and access. As an example, tags could be used to mark mice, cages, and litters as belonging to an experiment within a larger project. Another use-case would be for a lab supervisor to tag cages that require attention and let a technician remove tags as the task progresses. Additional information can be attached to records in core tables as user comments. Each record can be assigned numerous comments, tracked by user and date. These features are similar to those typically found on blogging or social networking Internet sites.

The system allows fine-grained control of access privileges. Users are assigned roles that define their privileges in the system and can be granted additional custom privileges. Privileges can be assigned for any action. Database integrity is enforced during system operation. A separate

Fig. 3 LAMA user interface examples. (A) The breeding cage page provides information about the breeding type and the animals currently present in the cage. Litters are entered by clicking the “Create New Litter” link which will automatically generate a new litter record linked to this breeding cage. (B) Each mouse has an individual mouse page where one can enter or change its status (e.g., killed) or add comments. From this page, mouse locations can be adjusted using the “move to cage” box. (C) On the litter page, information can be adjusted for individual animals (e.g., weaning status) and cards can be dynamically generated and printed

SQL-based script can be used offline to verify integrity of the entire database and reports on any issues found.

Installation requirements are Apache version 2.2.3, MySQL version 5.0.45, PHP version 5.1.6, Zend Framework version 1.7.4, and Dojo Toolkit version 1.2.3. The software is available at <http://launchpad.net/mousedb> without restriction.

System walk-through

LAMA is designed to provide flexible alternative approaches to data access or submission. The user can select one of the left-side menu options to access a query/submission page or use the provided search box (Fig. 2). This search

The screenshot shows the LAMA interface. On the left is a navigation menu with items: Strains, Mice, Breeding Cages, Litters, Wean List, Weaning Cages, and Search. The main area is titled 'Wean List'. It features a search filter for litters born between 19 and 21 days ago. Below this is a table of 10 litters. The table has columns: Qty, Litter, Born On, Weaned On, Alive Pups, Strain, Gen., Mating Type, and Assigned To. A 'Print Wean Cards' button is circled in red, with an arrow pointing to a detailed wean card for litter 8750-14. The card includes fields for Cage, Strain, Mother(s), Father, DOB, Gen., and Protocol.

Qty	Litter	Born On	Weaned On	Alive Pups	Strain	Gen.	Mating Type	Assigned To
<input type="checkbox"/>	11523-4	090619			B6-Alb	F6	Trio	Taryn
<input type="checkbox"/>	12290(1)-1	090619			mEMS3422			
<input type="checkbox"/>	8773-15	090619		3	B6-Alb			
<input type="checkbox"/>	10030-11	090620			ICR-a/Ems			
<input type="checkbox"/>	11837(5)-9	090620		10	mEMS3836			
<input type="checkbox"/>	6523-4	090620		6	BALB-frc			
<input type="checkbox"/>	7524-5	090620			B6-ROSA26			
<input type="checkbox"/>	8754-13	090620			B6-Alb			
<input type="checkbox"/>	12541(1)-1	090621			mEMS4449			
<input type="checkbox"/>	8786-11	090621			B6-Alb			

Fig. 2 LAMA left-side quick menu and weaning page. The left-side menu, present on all pages, allows users to quickly access, change, or add strains, mice, breeding cages, litters, wean lists, and weaning

cages. The wean list page dynamically outputs all litters needing to be weaned and provides an easy button to print wean cards to display on the cages

Breeding Cage 7853 A. Breeding cage page

Cage ID:

Active (deactivating will kill all breeders)

Set Up On:

Breeders present in this cage

Mouse	Alive	Sex	Strain	Min/MaxP	Geno.	DOB
JAX-10-11	Y	F	C57BL/6J			0811
Jax-10-38	Y	M	C57BL/6J			0811

Assigned stud: [Jax-10-38](#)

Move mouse: to this cage

[Create new litter...](#)

Litters born in this cage

Litter	DOB	Born	Alive	Total Females
7853-1	090213	5	3	2
7853-2	090331	9	8	4

Mouse 7846-4-1 B. Mouse page

Mouse ID:

Sex: Male Female

Alive

Status:

Born on:

Weaned on:

Terminated on:

Is chimera

Move to cage:

From litter [7846-4](#)

Parents

Mouse	Sex	Alive	Strain	Min/MaxP
7843-1-1	F	Y	C57BL/6J	
7843-1-2	F	Y	C57BL/6J	
7843-1-5	M	Y	C57BL/6J	

Current cage [7846-4:F:1/1](#)

Litter 7846-4 C. Litter page

Litter ID:

Born on:

Weaned on:

Breeding cage [7846](#)

Parents [change](#)

Mouse	Sex	Alive	Strain	Min/MaxP	Genotype	DOB	Wks	Gen
7843-1-1	F	Y	C57BL/6J			081020	37.6	F6
7843-1-2	F	Y	C57BL/6J			081020	37.6	F6
7843-1-5	M	Y	C57BL/6J			081020	37.6	F6

This litter is 3 weeks old on 090411, 6 weeks old on 090502

Weaned on 090411

	Female	Male
Weaned on 090411	3	1
Born in this cage 6		
Alive at wean 4		

Mouse	Sex	Alive	Status	Genotype	Cage
<input type="checkbox"/> 7846-4-1	F	N	IVF		7846-4:F:1/1
<input type="checkbox"/> 7846-4-2	F	N	IVF		7846-4:F:1/1
<input type="checkbox"/> 7846-4-3	F	N	IVF		7846-4:F:1/1
<input type="checkbox"/> 7846-4-4	M	N	sacrificed		7846-4:M:1/1

Last modified 090409 2:11 pm by Stephanie
[7846-1](#) [7846-2](#) [7846-3](#) [7846-4](#) [7846-5](#) [7846-6](#) [7846-7](#) [7846-8](#)

Strain:

Generation:

Protocol:

box can support queries of litter, cage, strain, or mouse identifier (mouseID). Alternatively, the Ajax-based interface will dynamically produce a drop-down list of items matching the query.

The interface is highly functional for frequent tasks. To support the process of weaning, the system generates a report indicating those litters of weaning age (Fig. 2). In order to prepare for both current and upcoming weans, the report can be specified for future days via drop-down date range displays. As many labs maintain card-based information within the animal facility, LAMA allows for the printing of cage cards for selected litters; it is accessible through both wean lists and individual litter pages (Fig. 2).

Convenient links are provided on each page to reach related records such as littermates, pups, strains, or breeding cages with a single click (Fig. 3). Various interface pages can be open in multiple browser tabs or windows to allow for easy referencing of information. Litters are entered into the database through their parental breeding cage record so that their lineage data and pedigree information is automatically tracked (Fig. 3A). Although the database currently does not have the functionality to create a classic pedigree chart, the lineage of each individual mouse can be tracked backwards and forwards. All mice that were born to a breeding cage within the database will retain the parental information on their individual mouse information pages (Fig. 3B), as well as information about their own litters and the location to which their pups were moved following wean. When litters are weaned, new mouse records are created that link back to the litter (Fig. 3B) and the user is able to batch change the genotype or status (e.g., sacrificed, dissected) for all littermates using the litter page (Fig. 3C). The genotype field is a text field and is used by manual entry of the genotype. For example, the genotype information for a ROSA26 heterozygote would be entered simply as “ROSA het.” This flexible mechanism is beneficial when entering composite genotypes describing multiple properties.

Mouse, litter, and cage name generation is implemented by customizable functions. Internally, the software tracks records and their relationships using unique IDs generated by the database engine; therefore, the displayed names are highly adjustable. For example, in our case, mice are automatically and uniquely numbered using the following scheme: “breeding cage# - litter# - mouse#”, where the breeding cage# assigned is the parental breeding cage# of the litter and is unique to each breeding pair. At the time of software installation, the function defining the displayed names can be modified to reflect the naming scheme of the breeding facility. The naming scheme can be modified at any time without affecting existing names or relationships between records. Users with appropriate permissions can overwrite the names generated by the custom function.

Mice can be manually created by users (such as mice arriving to the facility) and named as needed.

The physical locations of individual cage spots are not tracked because frequent physical relocation of cages renders such functionality ineffective for the current users. The system does allow for the delineation of the room, rack, and section of the strain on the strain page. Once a mouseID has been entered, either by automatic creation or by manual entry, the location may be specified or adjusted. For instance, a mouse’s location may be specified to a breeding cage by a simple click from the mouse record page (Fig. 3B) or through the breeding cage page (Fig. 3A). Each mouse is linked to a strain for which one can display and edit information on the strain page.

The search page is powerful and flexible (Fig. 4A, B), allowing users to query any field in the database. Search fields are implemented through a set of classes that greatly simplify addition of new ones: only three to five lines of code are required to enable searching on a new field in the database. Search criteria may be saved for future use. The output columns are customizable and search results can be exported to Excel worksheets. Query results (as well as any data displayed in tabular format system-wide) can be sorted interactively by clicking on column headings. From a user’s perspective, the search functionality is similar to an Internet search engine. Wildcard and Boolean searches are supported. For researchers familiar with relational databases, one may specify an SQL WHERE clause in this text box by starting the entry with “!”. A “tag cloud” can be displayed, which provides access to consolidated listing of all records with a given tag, regardless of record type (Fig. 4D). The current focus of the search feature is to list records matching specified criteria for immediate access or, in case statistical analysis or other aggregation is needed, to allow export of selected records in spreadsheet format.

A separate search feature (“Quick Search”) is available on each of the landing pages for mice, cages, strains, and litters sections (Fig. 4C). Here, search terms are entered in a single text box and matched against any of the fields in appropriate tables. Queries made via Quick Search have search terms embedded in URL to facilitate bookmarking.

Discussion

LAMA has been designed as a LIMS to help research laboratories manage mouse colonies. Due to the flexible implementation, it can be readily altered to support diverse animal management applications, allowing researchers working with model organisms as diverse as fish and butterflies to organize their studies. Because a litter record is associated with a breeding cage and not individual breeders (males or females), researchers may utilize the software for

Fig. 4 LAMA search features. (A) The search page produces extensive search capabilities with specific searches for different records (e.g., breeding cages, mice, or litters). (B) This screenshot illustrates an example search for active breeding cages with IDs starting with “11” and containing a male from the “C57BL/6 J” strain. The search results are displayed at the bottom of the page with a specific set of selected output columns and can be saved and/or exported to a text file or Excel sheet. (C) Example of “Quick Search” using a SQL WHERE clause. (D) Tags allow users to quickly segregate subgroups of mice or cages. In this example, all breeding cages containing “GL Chimera” were tagged and retrieved using the tag

A. Generic search page

Search

New Search:

[Strain](#) | [Mouse](#) | [Litter](#) | [Breeding Cage](#) | [Weaning Cage](#) | [Transfers](#)

Show searches created by:

Type	Title	Public	Author	Modified on
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B. Specific breeding cage search page

New Breeding-cage Search

Title:

Allow other users to see this search

Search Fields

Cage ID: starts with

Active: yes

Set Up On:

Set Up (days ago):

Breeding Type:

Mating Type:

Female Strain:

Male Strain: is

Protocol:

Tag:

Comment:

Modified By:

Modified On:

Output Columns

Cage ID

Mating Type

Modified On

Limit results to

95 records found

Cage ID	Breeding Type	Mating Type	Female Strain	Male Strain
11127	Breeder	Trio	mEMS1606	C57BL/6J
11137	Breeder	Trio	mEMS1607	C57BL/6J

C. Quick Search feature

Search Mice

29265 results found for *! sex = "F" and born_on > "2008-08-06"*

Mouse	Sex	Alive	Status	Strain
10001-1-1	F	N	MI Team	ICR
10001-1-10	F	N	MI Team	ICR
10001-1-2	F	N	MI Team	ICR
10001-1-3	F	N	MI Team	ICR
10001-1-4	F	N	MI Team	ICR
10001-1-5	F	N	MI Team	ICR
10001-1-6	F	N	MI Team	ICR
10001-1-7	F	N	MI Team	ICR
10001-1-8	F	N	MI Team	ICR
10001-1-9	F	N	MI Team	ICR
10001-10-1	F	N	holding	ICR-a/Ems

D. Search by tag

Items tagged with GL Chimera

Strains

Mice

Breeding Cages (114)

Litters

	Cage	Active	Breeding Type	Mating Type	Setup Date	Modified on
Wean List	10710(1)	N	Female Rotation	Trio	081126	090227 5:53 pm
Weaning Cages	10736(1)	N	Female Rotation	Trio	081128	090220 5:15 pm
Search	10744(1)	N	Female Rotation	Trio	081205	090423 3:33 pm
	10745(1)	N	Female Rotation	Trio	081205	090423 3:33 pm
Enter an item ID:	<input type="text" value="10750(1)"/>	Y	Female Rotation	Trio	081205	081205 4:30 pm
	<input type="text" value="10759(1)"/>	N	Female Rotation	Trio	081205	090423 3:32 pm
Tags	10770(1)	N	Female Rotation	Trio	081210	090611 3:47 pm
EESC derivation strain	10784(1)	N	Female Rotation	Trio	081223	090611 3:35 pm
	10784(1)	N	Female Rotation	Trio	081218	090423 3:31 pm

either a female-oriented (i.e., males moving through female cages) or male-oriented breeding approach.

As the database schema revolves around four main core tables (animals, cages, litters, and strains), LAMA can be easily extended to track associated data. For example, the

schema supports the generic notion of a cage as a container for one or more animals, of which two instances, breeding and weaning cages, are currently implemented. It could be extended to support other types of containers such as holding or observation cages with relative ease by creating

an additional table to store information specific to this container and deriving from the Cage class, following the coding pattern already in place.

LAMA was designed to facilitate the studies of research laboratories rather than increase the efficiencies of animal facilities. Due to this focus, the initial release does not track room capacity or availability of specific cages. Such functionality, however, would be possible to implement. It is our vision that many research groups sharing a common animal facility would utilize LAMA. Each group could independently install LAMA and use it for the management of their colonies.

Plans for future development include the integration of complex data types into the system to allow for the detailed description of alleles, support for image-related meta-data, and the incorporation of bar code management tools to enable the identification of cages and animals using scanning devices.

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References

- Bishop BS, Hanna MG Jr (1968) Computer program for inbred and-or hybrid animal breeding and production colonies. ORNL-TM-2210. ORNL-TM [reports]. U.S., pp 1–145
- Boulukos KE, Pognonec P (2001) MICE, a program to track and monitor animals in animal facilities. *BMC Genet* 2:4
- Ching KA, Cooke MP, Tarantino LM, Lapp H (2006) Data and animal management software for large-scale phenotype screening. *Mamm Genome* 17:288–297
- Hopley R, Zimmer A (2001) MouseBank: a database application for managing transgenic mouse breeding programs. *Biotechniques* 30:130–132
- Maier H, Lengger C, Simic B, Fuchs H, Gailus-Durner V et al (2008) MausDB: an open source application for phenotype data and mouse colony management in large-scale mouse phenotyping projects. *BMC Bioinformatics* 9:169
- McKie MA, Webb S (1999) LAMS(TM)—a laboratory animal management system. *Mamm Genome* 10:349–351
- Montoliu L (2003) Simple databases to monitor the generation and organisation of transgenic mouse colonies. *Transgenic Res* 12:251–253
- Pargent W, Heffner S, Schable KF, Soewarto D, Fuchs H et al (2000) MouseNet database: digital management of a large-scale mutagenesis project. *Mamm Genome* 11:590–593
- Silver LM (1993) Recordkeeping and database analysis of breeding colonies. *Methods Enzymol* 225:3–15