

Challenges of training quantitative graduate students

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EDITORIAL

Shortage of quantitative geneticists in animal breeding

More and more I receive phone calls from various breeding companies looking to hire a PhD in quantitative genetics. They inquire if I know of a graduate versed in quantitative genetics and mixed models, with some programming skills, who can speak and write passable English, has a general understanding of markers and molecular genetics, can run and troubleshoot a genetic evaluation, and in general be a problem solver. I do not know of anyone available, I reply. There were many of them 10–15 years ago, but now they are rare. If they show up, they usually have very good offers well before graduation. My colleagues outside the USA are telling me of similar problems, although the severity of the PhD shortage is country dependent.

Great hopes were put into finding markers for major genes (QTL) that could help solve the new challenges. Based on many association studies, there is growing consensus that few markers/QTLs can be detected, those that were detected had their estimated effects inflated, and that the benefits of using markers are limited. Of all markers found, very few were for low-heritability traits.

The new trend in animal breeding is genomic selection using SNP chips. In this methodology, one estimates effects of individual haplotypes, and genomic EBV (GEBV) is estimated as a sum of those effects. No effort is made to identify QTLs. The genomic selection is based on an assumption opposite from the previous effort in markers but the same as in 'black box' genet-

EDITORIAL

Can we rescue an endangered species?

The timely editorial by Ignacy Misztal (*J. Anim. Breed. Genet.*, 124, 255–256) on the current shortage of quantitative geneticists in animal breeding is alarming. We in the field have been well aware of the problem for some time, but how to correct this trend is a formidable challenge. There are several reasons for the present situation. A major factor is that funding for research and training of graduate students in quantitative genetics and animal breeding (QGAB) began to decline as molecular genetics took center stage in the early 1990s. The prevailing view was that molecular genetics would soon solve all relevant problems in animal breeding. Experience has shown this assumption to be incorrect. Although molecular genetics has become a very important tool for understanding quantitative genetic variability, there are still many research questions that require a firm foundation in QGAB. There is a shortage of well-trained quantitative geneticists to meet all the demands of industry. It is imperative that government agencies and breeding companies that rely on qualified quantitative geneticists for their survival recognize the seriousness of the situation. Otherwise,

we will have a strong commitment to agriculture, must be apprised of the economic impact of QGAB research. To do so most effectively, professional societies such as the American Society of Animal Science and the European Association for Animal Production should appoint a commission of experts to study the problem and make appropriate recommendations to federal funding agencies on the importance of funding research and graduate training in QGAB. In this regard, the commission should look at the global picture of how past research in QGAB has improved the genetic quality and yield of food and fiber obtained from domestic animals, including aquatic species such as oysters and shrimp. Quantitative geneticists in animal breeding are specifically trained in aspects of application to animal genetic improvement that are generally not in the purview of molecular biologists. For this reason, the commission should also explore the economic benefits for research collaborations between well-trained quantitative geneticists and molecular geneticists. This point is particularly relevant in light of the current push to complete the gene sequencing of food ani-

Shortage of quantitative geneticists (QG) in animal breeding

- Companies
- Governmental institutions / USDA
- Not yet academia

- Worldwide but with different intensity

Applies to graduates with sufficient skills

What to do?

History

- Up to 1980s - Golden years for QG
- 1990 – Molecular genetics / Major gene concept
 - Excitement
 - Different set of skills
 - Shift of funding
 - Much larger grants with indirect costs
- 1990s – overproduction of QG graduates (?)
- Hiring of QG graduates by non-animal industries

Current situation in QG

- Little or no competitive funding
- Very few academia hires
- Very few applicants for graduate programs
- Few places with critical mass for training

- End of QTL/major gene era
- Serious issues in breeding neglected
 - Loss of fertility, longevity and resistance to diseases across species
 - Nonlinear relationship among traits
 - GxE issues (nucleus, commercial), (moderate, challenging), (hot,cold)
 - Drawbacks in genetic evaluations

Genomic selection (GS)

- Based on regular EBV
 - bad EBV = bad genomic prediction
- Results at AIPL (VanRaden et al., 2008)
 - Accuracy up to 70s with many high reliability bulls and good panels
 - Infinitesimal model a good approximation
 - Simple models - equivalent to single trait sire models
- Realistic analyses currently too complex with GS
- Increased importance of low heritability traits Will GS be applicable? Failure with QTL studies...

GS one of tools for improvement, with limits

GS requires quantitatively trained scientists

Why few applicants for graduate studies in US?

- Fewer students with farm background
- Discouragement from old graduates
- Few universities with critical mass and exciting research
- Increasing cost of graduate students

- International developments
 - EU/AU sites strong academically
 - Relatively low graduate assistantship pay in US
 - US \$ weak
 - Immigration issues past 9/11

Tempting response: Lowering standards for admission...

For some applicants, studies not first priority

How to train graduate students we have?

“If you want to build a ship, don’t drum up the men to gather wood, divide the work and give orders. Instead, teach them to yearn for the vast and endless sea.”

- *Antoine de Saint-Exupery*

Issues in training

- Are many long courses beneficial?
- Ways of training
 - Advisor-student interaction
 - Peer group interactions
 - Seminars
 - Meetings
 - Courses
- Which courses will stand the test of time?

Sample sequence of courses in animal breeding

- Math
- Statistics – basic and advanced
- Quantitative genetics
- Mixed models
- Advanced methods
 - General
 - Bayesian
 - Molecular
- Programming (?)

Value of various delivery methods

- Formal courses
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Which method best?

- Choose teaching methods from country with perhaps most productive graduates: Spain
- Why short courses:
 - Critical mass
 - Social environment
 - Expert instructors
 - How long?
 - % benefitting from short courses? why?



Issues in short courses

- Timing
- Travel costs
- Tuition costs
- Formal credit
- Social program

- Course overload

How to increase the number of graduates?

- Increase applications
 - Disseminate info on employment opportunities
 - Active recruitment
 - More generous assistantships (like in EU)
 - Generous research/education support
- Enable new faculty hiring at universities
 - New pool of funds (incl. indirect)
- Motivate and utilize existing faculty
 - Short courses
 - Generous support for sabbaticals

Funds

- Almost no federal grants for quantitative projects
 - USDA, NSF,...
- Single PI vs. integrated grants
- Matching funds for industry grants
- Specific funds for graduate training (industry sponsored or federal)
 - Example of graduate students in Gembloux, Belgium
- Industry funds overseas (e.g., Netherlands or Canada) and in US – single vs. multiple beneficiaries
- Direct funding vs. lobbying

Real shortage or just cyclical development

- History of 5 recent graduates from UGA
 - Extension faculty (1 PhD)
 - USDA, then companies (1 PhD)
 - Statistical consulting (2 MS)
 - Large plant company, after 2 unsuccessful faculty interviews (PhD)
- Why little support from industry?
 - Little need?
 - No attractive programs?
 - Free help available
 - Short-term outlook?

Ideas from editorial by Eugene Eisen

- Shortage of QG limited to animal field
- Need to recruit top talent - competition
- NSF may be persuaded to fund QG AB projects
- Industry support vital
- Create ASAS/EAAP committee to study issues
- Little time - 5 yrs to train PhD

Conclusions

- Quantitative work still provides most revenue to industry
- Quantitative training crucial for genomic selection
- Shortage of quantitative geneticists dangerous for the US industry
- Time to set committee for addressing shortage

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Options for existing quantitative faculty

- Switch (with hype)
- Do nothing
- Do little
- Do everything, day and night
 - Frustrations of magnitudes: 1 mln vs 50k
- Consulting model

- Molecular genetics:
 - very simple models
 - Important issues not solved
 - GS one of tools of improvement: limits
 - Cannot graduate asst prof with anim breed grants (Quaas, 2004?)