ニュージーランド

Textile Science in New Zealand

Wool Research Organisation of New Zealand

G. A. Carnaby

A. J. McKinnon

1. GROWTH AND BIOLOGY OF WOOL FIBRES

Improvement of wool quality and the efficiency of sheep as converters of grass into fibre has been a preoccupation of wool breeders since antiquity. In New Zealand intensive sheep breeding has been a major aspect of our industry for over one hundred years so that now most of the sheep are genetically superior animals. A Government Research Institute, AgResearch, mounts programs on all aspects of sheep farming with growing emphasis on molecular genetics, gene mapping [1] and transgenic [2] technologies. These new biological techniques suddenly promise the potential for much more rapid progress in altering sheep and wool in response to changing market requirements.

In order to fully exploit this new genetic technology, there is a renewed effort at both AgResearch and WRONZ (Wool Research Organisation of New Zealand) to better understand the linkage between specific genetic markers [3] and the expression of those genes in terms of the structural and biological features of the individual fibres.

2. STRUCTURE AND CHEMISTRY OF THE WOOL FIBRE

It is an inescapable fact that wool fibres are formed as a composite of several different cell types, especially cuticle cells and the ortho and para cells of the cortex. Much ultrastructural work at WRONZ [4] and elsewhere has clarified many of the structural features of these cells. The clear recognition of the differences between the keratinous and non-keratinous protein components of these cells [5] and of their significance in processing has been one of the useful outcomes of such research.

This cell composite is connected by an inter-cellular cement formed from the much-modified remnants of the plasma cell membranes of the follicle. A strong trend in wool research over the last 15 years has been the elucidation of the behaviour of this cell membrane complex in fibre chemistry and in mechanical performance [6]. It is now clearly appreciated that it is important in both areas. A major effort at WRONZ has been devoted to further understanding the structure and composition of the CMC which contains several differentiable layers [7]. As the CMC material constitutes only about 1.5% of fibre mass, its preparation and analysis has proved extreme-

ly difficult. Some progress has been made, however, in understanding the chemistry of both the lipid and protein components of the CMC [8].

Tremendous advances occurred through the 1980s in wool fibre structure and chemistry when it became recognised that the 'microfibrils' of wool fibres were structurally and chemically closely related to the 'intermediate filaments' found in many other epithelial tissues [9, 10]. This allowed a fusion and cross-fertilisation to occur between wool fibre chemistry and other areas of biochemistry and cell biology. Unfortunately, the wool industry was not able to fully capitalise on these rapid advances, as simultaneously basic wool protein chemistry studies in Australian laboratories were being terminated.

WRONZ has recently developed its own programme in wool protein chemistry, with the principal aim being to develop improved 2D-gel electrophoresis separation methods for wool protein, as a prelude to characterisation of all the 200 or more fibre proteins, both intermediate filament (IF) protein, from the fibril portion of the structure, and the intermediate filament associated proteins (IFAPs) from the matrix. These advanced 2D separation methods [11], coupled with exciting new techniques for rapid screening and characterisation of large numbers of proteins, based on highly accurate and sensitive amino-acid analysis, partial sequencing, and mass spectrometry, offer the prospect of rapid advances in understanding the protein composition of fibre. This can then be related back to the expression of keratin genes located by nucleic acid research, and to modifications of the protein occurring after genetic translation. For instance, we have recently found in our programme [12] that some IF proteins are either phosphorylated or intermediate filaments assemble *in vivo*.

3. MECHANICAL BEHAVIOUR OF ASSEMBLIES OF FIBRES

New Zealand wool fibres are converted mainly into carpets or knitwear. Because of the difficulty at least until recently, in changing the fibre

properties within the national flock, intensive research has been conducted over many years at WRONZ in order to better appreciate how the same fibres can be manipulated and formed differently into more effective assemblies; assemblies with better mechanical performance or improved consumer product features. Underlying the technology efforts has been an openly published WRONZ contribution to the mechanics of textile fibre assemblies, ranging from the properties of the unit fibrous cell, through yarn mechanics to the physics of carpets and knitwear.

Recent advances have focused on further improvements to the two main techniques of analysis for understanding the mechanical response of yarns [13].

A new continuum mechanics model [14] of the yarn based on application of a modal adaptation of the finite element method has recently been submitted for publication.

At the same time the "shortest path hypothesis" has again been applied in a new discrete fibre model of yarn torsional behaviour [15].

4. FUTURE PROSPECTS

Past wool science research in New Zealand has been heavily exploited in successful commercial developments which have added great value to the production and conversion of the national clip.

The New Zealand Government in particular is committed to policy of open publication of more basic research where this may contribute to the global pool of scientific expertise. Both major institutions, WRONZ and AgResearch, reflect this culture in maintaining strong basic research teams which link consumer requirements at the final product right back to genetic manipulation of the national flock.

Although profitability of sheep farming in New Zealand has been quite poor over the last few years, renewed and refocussed national and international programmes of marketing and technology development promise to both further

differentiate New Zealand wool and advantage those companies who utilise it.

Acknowledgement : Some of our ideas for linking our various basic research programmes have been developed in partnership with Professor J. W. S. Hearle who acts as a consultant to WRONZ.

REFERENCES

- 1) T. E. Broad, G. W. Montgomery, A. M. Crawford and D. F. Hill (1995) ; Current state of the New Zealand sheep genome programme. Proceedings of the Australian Association of Animal Breeding and Genetics, 11, 458-464.
- 2) S. Damak, N. P. Jay, G. K. Barrell and D. W. Bullock (1996) ; Targeting gene expression to the wool follicle in transgenic sheep. Bio/Technology 14 : 181-184 ; and S. Damak, H.-Y. Su, N. P. Jay and D. W. Bullock (1996) Improved wool production from transgenic sheep expressing insulin-like growth factor I. Bio/Technology 14 : 185-188.
- 3) G. R. Rogers, J. H. Hickford, R. Bickerstaffe (1994) ; A potential QTL for wool strength located on ovine chromosome 11. World Congress on Genetics Applied to Livestock Production. 21 : 291-294.
- 4) R. C. Marshall, D. F. G. Orwin and J. M. Gillespie ; Structure and biochemistry of mammalian hard keratin. Electron Microsc. Rev., 4, 47-83, (1991).
- 5) H. Zahn ; Plenary Lecture, 'Wool is not Keratin only'. 6th Int. Wool Text. Res. Conf., Pretoria 1980.
- 6) J. D. Leeder ; The CMC and its influence on the properties of the wool fibre. Wool Science Review, 63, 3-35 (1986).
- 7) W. G. Bryson, S. J. McNeil, A. J. McKinnon and D. A. Rankin ; The cell membrane complex of wool—a critical assessment of the literature. WRONZ Comm. C123, September 1992.
- 8) W. G. Bryson, J. L. Woods, W. G. Nelson, G. L. Krsinic, D. A. Rankin, B. R. Herbert and A. L. P. Chapman ; The enzymatically isolated cell membrane complex—myth or reality. Presented at the 21st Annual Lorne Protein Conference on Structure and Function, Australia, 1996.
- 9) G. E. Rogers, P. J. Reis, K. A. Ward and R. C. Marshall (Eds) ; The biology of wool and hair, Chapman and Hall, London 1989, Chapters 6-11, Keratin Proteins.
- 10) D. A. D. Perry and P. M. Steinert ; Intermediate Filament Structure. Springer Verlag/R. G. Landes Company. 1995.
- 11) B. R. Herbert and J. L. Woods ; Immobilised pH gradient isoelectric focusing of wool proteins. Electrophoresis, 15, 972-976 (1994).
- 12) B. R. Herbert and N. H. Packer ; Characterisation of wool intermediate filament proteins separated by two-dimensional electrophoresis. Presented at the 21st Annual Lorne Protein Conference on Structure and Function, Australia, 1996.
- 13) G. A. Carnaby, F. Choi, W. A. Munro, A. J. Carr, P. J. Moss and S. K. Tandon ; The Mechanics of Yarn Torsion. Proceedings 23rd Textile Research Symposium at Mt. Fuji. 79-86. 1994.
- 14) W. A. Munro, G. A. Carnaby, A. J. Carr, P. J. Moss ; Finite Elements for Aligned Fibre Assemblies. Submitted to J. Text. Inst. 1995 ; W. A. Munro, G. A. Carnaby, A. J. Carr, and P. J. Moss. Finite Elements for Yarn Mechanics. Submitted to J. Text. Inst. 1995.
- 15) S. K. Tandon, G. A. Carnaby, S. J. Kim, F. K. F. Choi ; The Torsional Behaviour of Singles Yarns, Part 1 : Theory. J. Text. Inst. 86 : 185-199. 1995.

ジェットルーム織布 (Jet Loom Weaving)

——ジェットルームを中心とした製織技術・関連技術のすべて——

A5判260頁, 4,120円 (本体4,000円, 送料400円)

織布の現状を知り将来を考えることを目的とし, 専門家には織布ハンドブックとしての役目を果たし, 向学の人々には分かりやすい参考書となることを念じて編さんした。(1)展望, (2)準備工程, (3)エアジェット織機, (4)ウォータージェット織機, (5)関連技術と資料の全5章に分けてやさしく記述している。

ご購入の方は下記宛, 書籍名を明記し, 代金, 送料をご送金頂ければ折り返し送本します。

日本繊維機械学会 (〒550 大阪市西区靱本町1-8-4, 大阪科学技術センタービル, TEL. 06-443-4691, FAX. 06-443-4694)