Status of Satellite Cell Research in Agriculture

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Key words: skeletal muscle, satellite cell, domestic animals, poultry, fish.

BAM 5 (1): 5-9, 1995

For centuries, meat-producing animals have been phenotypically selected for efficiency of feed conversion, variables of carcass quality and yield of total carcass lean (meat). Research in animal nutrition and animal genetics flourished and, until recently, provided the core of knowledge presently available concerning muscle growth dynamics in meat-producing animals. Today, research in allied animal science disciplines such as muscle biology or animal growth biology are providing additional details of cellular muscle growth mechanisms, including participation of myogenic satellite cells [38] in facilitating postnatal muscle growth.

The major postnatal muscle growth component for traditional meat animals is hypertrophy [50], but in fish myofiber hyperplasia may occur as a normal mechanism of growth until late in adulthood [24, 33, 34, 53, 55]. Satellite cells appear to be important during both myofiber hyperplasia and hypertrophy. They enhance the myonuclei population and thereby facilitate protein accretion in normal myofibers during hypertrophy [47, 48] and appear to be responsible for myofiber hyperplasia and regeneration [3, 4, 8, 34, 36, 38].

Studies with satellite cells from laboratory species [3, 25, 59] have translated to successful experiments with domestic animal-derived satellite cells [Table 1]. Meat animal-derived satellite cells possess characteristics similar to satellite cells from laboratory species. The *in vivo* locale, positioned adjacent to myofibers and wedged between the sarcolemma and basement membrane, the high nuclear: cytoplasmic ratio, type and amount of cytoplasmic organelles, and distribution of cells in muscle as a function of age appear to be homologous across species [1, 8, 38].

Methods used to isolate domestic animal-derived satellite cells for subsequent study in cell culture were adapted from techniques originally established for isolation of rat satellite cells [2, 6, 13, 14, 15, 22, 31, 40, 59]. Most domestic animal satellite cells require a protein substratum for attachment to cell cultureware [12, 14, 15, 22, 40]. Following attachment, satellite cells appear to be capable of proliferation in response to increasing levels of serum contained within traditional growth media [39]. Further, differentiation of satellite cells seems to be triggered by serum reduction methods [2, 3, 14, 15, 39]. Other *in vitro* characteristics include the capability of satellite cells to remain viable in serum-free defined medium [3, 11, 43], and comparable responses of cells to individual growth factors contained within the defined medium [4, 10, 17, 21, 39, 43].

Although many similarities exist between satellite cells from all animals, it is difficult to extrapolate satellite cell culture data from system to system. Species differences account for some of the variability observed between systems. For example, chicken-derived satellite cells require chicken embryo extract for growth to occur in culture [26, 27, 29, 59]; chicken satellite cells lack a type II IGF receptor [18, 20], and beef cattle-derived satellite cells

Table 1: Summary of agriculturally-important animal satellite cell research with references associated to different scientific emphasis areas.

RESEARCH AREA	REFERENCE
A. *In vivo:*	
(morphology/comparative/ physiology)	7,8,9,32,37
B. *In vitro:*	
1. Cell culture system development	
-sheep	11,12,13,30,35,45,46,52
-beef	5,14,21
-turkey	16,40,41,42,43,44,54
-chicken	18,19,26,27,28,29,36,59
-horse	22
-pig	10,15,17
-fish	23,31,51
2. Myogenesis studies	
-cell cycle regulation (activation/proliferation/differentiation)	2,10,11,12,17,20,21,28,30,33, 40,41,42,43,58,59
-Myotube maturation (protein profile regulation)	5,26,27,36,45,46
3. Metabolism studies	18,19,52
4. Myogenic cell comparison	
-embryonic myoblasts to satellite cells	26,29,42,49,54,57
-satellite cells to satellite cells	27,33,45,46
-satellite cells from different animals	5,11,16,35,41
C. *Review Papers*	3,4,8,39,56

respond inconsistently to TGF-B and other growth factors [21]. Data also suggest that meat-type animals such as chickens [27], sheep [45, 46] and fish [33, 34] possess different subclasses of satellite cells, which may be activated by different muscle growth requirements [33, 34]. These examples illustrate that meat animal-derived satellite cells display distinct physiological properties, that if further exploited, may aid in defining novel aspects of postnatal myogenesis.

Currently, research with meat animal-derived satellite cell systems is focused on three priority areas. The first priority area is definition of the mechanisms involved in activating satellite cells from a dormant to a proliferating condition. Research in this area includes devising more efficient and repeatable methods to isolate satellite cells from a variety of individual muscles, determining optimal conditions for isolated satellite cells to attach and survive *in vitro*, elucidation of the presence of satellite cells that are derived from different lineages that might possess different biochemical and biophysical properties, and definition of activating factors that promote satellite cell transit through the cell cycle. The second priority area is definition of regulatory factors that influence satellite cell proliferation and differentiation in cell culture. Factors that have been identified to exert muscle growth effects *in vivo* have been screened for effects on satellite cells *in vitro* and mechanisms of action are now being defined. Most of the resources available for domestic animal satellite cell research are derived from agencies interested in future exploitation of data derived from this research area. The third priority involves the study of the regulation that satellite cell-derived myonuclei exerts on myofibers, during events facilitating myofiber hypertrophy. For researchers studying domestic animal-derived satellite cells, application of long-term research endpoints are likely to 1) provide practical ways to enhance the efficiency of lean muscle growth and thereby reduce feeding of energy and protein sources to meat animals; 2) enhance the body composition of meat animals to improve the yield of edible product; 3) improve meat quality; 4) provide alternative method(s) or criteria for genetic selection of replacement animals; 5) serve as important comparison systems to identify mechanisms for muscle response to exercise; and 6) serve as models for human myopathy research.

In summary, a complete understanding of mechanisms involved in postnatal skeletal muscle growth in domestic animals requires knowledge of how myogenic satellite cells participate in the growth process. As domestic animal-derived satellite cell culture systems become available, their utility in addressing variables of satellite cell involvement in postnatal muscle growth mechanisms will be recognized. This compilation of research articles is an attempt to examine characteristics of myogenic satellite cells from several meat-producing domestic animals, including data from avian, horse and fish species as these animals provide considerable amounts of edible protein, worldwide. Contributors of this *BAM* volume appreciate the opportunity to share basic and applied data, collected from use of animal-derived satellite cell systems.

Acknowledgments

The assistance of Ms. L.L. Clark and Ms. J. Hume in manuscript preparation is appreciated. Washington State Agricultural Research Center paper number 8095.

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