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ABSTRACT

Allowing animal patents provides potential benefits and costs for livestock producers. Costs, considered here, are royalty payments and collection mechanisms, made more complex by the unknown future distribution of multiple patented traits in the herd. This article evaluates three proposed collection systems, Qualified Sales, registration and pooled royalties. The first two are imposed only on breeding stock and at first sale, creating a cash flow and risk factor for producers. The third collects payments from all animals at point of slaughter, based on traits in a sample. It favors producers at the cost of delayed payments to the patent holders. The eventual system used will depend on the cost and speed of testing for patented traits.

ROYALTY COLLECTION FOR PATENTED LIVESTOCK

INTRODUCTION

When on 3 April 1987 the Board of Patent Appeals and Interferences of the U.S. Patent and Trademark Office (PTO) declared on internal appeal[1] higher animals to be patentable subject matter, livestock producers and related enterprises responded with mixed emotions. Producers' support is expressed in the public position of the American Farm Bureau Federation, the largest farmers' group in the United States representing all aspects of agriculture. The Farm Bureau "...support[s] the granting of animal patents if they act as an incentive for the commercialization of genetically improved animal breeds" (Sorensen 1987, p. 121). Underlying this position is a belief that biotechnology can hasten the feed conversion efficiency and disease resistance of livestock at a time when the decline in red meat consumption in particular is at least partially attributable to cost factors (Ikerd 1987). At the same time there is a concern that patent rights will limit the flexibility producers have over the use of their animals and increase the paperwork requirements of farmers as they struggle to record the genetic background of each of their animals for royalty payment purposes. In Sorensen's words, if the adopted royalty collection system "...means excess paper work for the farmer, the system will likely be rejected" (Sorensen 1987, p. 121). The National Cattlemen's Association went even further in urging Congress to exempt domestic beef cattle from royalties.

The conundrum agribusiness interests find themselves in is supporting the potential benefits from patent rights for animals through the stimulation of additional private funds invested in research on improving animal breeds while resisting (and even rejecting) the assessment of royalties. Regrettably one cannot have both, for royalties are the predominant means by which inventors benefit from patented inventions, the return for which they invest in research and development (R&D). That anomaly has been widely acknowledged and at least three alternative approaches to the assessment and collection of royalties on livestock have

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1 *Ex Parte Allen* Appeal No. 86-1790.

been proposed, one by the Farm Bureau Federation, one as an amendment to the U.S. Patent Act and one proposed earlier by the author. The purpose of this paper is the institutional and economic appraisal of these proposals to determine their implications for royalty collection, the costs and efficiency of collections, and any possible impacts on the structure and location of livestock production. The analysis is limited to the United States because it is the most likely for the foreseeable future to issue a patent for livestock although to date only laboratory animals have been granted patents.[2]

Livestock are not the only classes of animals affected by patents and royalty payments. Three additional groupings come immediately to mind, racehorses and other animals for sport/show, laboratory specimens used in medical and related research, and genetically altered animals used to produce pharmaceutical protein products.[3] In the last case, human factor IX produced in sheep's milk was first (Clark *et al.*, 1989).[4] However, these animal classes, while of the utmost social significance, present less complicated royalty collection procedural issues for the patent system than do livestock. Experimental animals, for example, represent a very small percentage of the hundreds of millions of dollars required to earn regulatory approval of pharmaceutical products so that their cost is not so critical. Moreover, national requirements for t-PA, an anticoagulant for treating circulatory ailments, could, it has been estimated, be produced by a 100 cow herd (Thompson 1987, pp. A1, A12) which could be held internally by a pharmaceutical company, avoiding the entire patenting/ licensing procedure. Brood and/or feeder animals, on the other hand, are a major production cost for livestock producers, representing some 63 percent of the cost of producing a market-ready steer in 1992 (USDA, ERS 1992, Table 31). At the same time the size of the U.S. livestock sector is very large,

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2 The situation regarding the patenting of animals is summarized in U.S. Congress (1989). More recently in Europe the issue has become further complicated by the uncertain application of a morality standard. See Crespi (1992).

3 For an overview of the operation of these sectors see Lesser (1993(a)).

4 This protein promotes blood clotting and is used in the treatment of hemophilia B.

involving 1991 farm sales of $80 billion and over one million farms spread across all 50 states (USDA 1992, Tables 392, 407, 424, 471 & 506). Thus royalty collection in agriculture production presents the greater challenge and is the subject of this analysis.

Before proceeding to that evaluation it is necessary to determine if indeed royalties are owed on patented animals. Without attempting a legal analysis (See Bent *et al.* 1987, pp. 279-85), the answer appears to be yes. Under the applied license interpretation of a patent license, the licensee has the right to use the product/process for its intended purpose, which for livestock is the production of meat, milk or eggs. Since the farmer involved in the production of these products need not reproduce them, reproduction would seem to require permission of the patent holder which can be expected to involve a royalty payment. Just how the courts would interpret the cases of dairy cows, which must calve annually to maintain milk production, and breeding stock which, by definition, is for procreation, is less clear. But in the main it appears that anyone who reproduces a patented animal is potentially liable to pay a royalty to the patent holder under a licensing agreement.

If the inventor has the right to demand a royalty then he/she also has a right to refuse permission. Livestock producers are then justifiably concerned that the right to breed will be denied. In the case of poultry such a denial is feasible because a hen can produce over 200 chicks a year. In fact under current practices with non-patented animals, many producers do not produce their own chicks. (See section below for more detail on the operation of poultry production). Cows, however, produce but one calf a year so that a third of the beef herd at any one time is utilized in maintaining itself (USDA, ERS 1992(b), Table 4). With such a low reproduction rate in that sector, it would be impractical for the patent holder to prohibit cow owners from producing calves. Therefore, patented livestock are unlikely to affect the operational activities of the sector, only the payment method.

As a prelude to the analysis it is necessary to describe in some detail the structure and operation of livestock production. As was suggested above, the description must be on a species-by-species basis. That is undertaken in the following section. The three proposals for royalty collection are evaluated in the next, or third, section and the fourth section presents the conclusion.

Prior to immersing ourselves in issues of royalty collection it is important to recognize that they represent but one part of concerns expressed about animal patents. Other concerns range from charges of unethical behavior to undue animal suffering to loss of genetic diversity (See Macer 1990). A treatment of those matters is left to other writers (See e.g. Brody 1990).

STRUCTURE OF LIVESTOCK PRODUCTION[5]

The $80 billion U.S. livestock sector can be divided by species and major use – beef cattle, dairy cattle, hogs, laying hens and broilers[6] – as well as by method of production and breeding/propagation. Each of these designations has a different operational procedure and structure, necessitating separate treatment. The following material is provided to give an overview of the livestock sector to provide a better understanding of how royalty payments could be collected.

Breeding/Propagation

If this term is a bit cumbersome it is because two interrelated activities are combined in different ways by species. Poultry for example are "scientifically bred" (explained below) with breeding stock provided to large farms which produce chicks in a hatchery operation under the same ownership. Beef cattle, at the other extreme, are produced by specialized breeding-stock operations which sell bulls to individual calf producers who make the breeding decisions. Dairy cattle and hogs combine aspects of these two along with the use of artificial insemination in different degrees. For our purposes here then the term breeding/propagation refers to both the

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5 Much of the background material presented here is drawn from my livestock marketing text (Lesser 1993(b)), and other references on the subject, e.g., McCoy (1981); Purcell (1990).

6 Sheep, turkeys and ducks as well as less common products like game hens and rabbits are not considered here because they are numerically so much less abundant than the included species and classes.

production of young animals as inputs (propagation) as well as the selection of mates (breeding).

Beef Cattle: The production of beef involves two quite distinct stages. Brood cows are maintained on grazing land (especially in the northern plains and southeast) where calves are grown out until they reach about 600 pounds. These are known as cow-calf operations. The fattening or "finishing" is done in feed lots until the animals are brought up to slaughter weights of 1,100 pounds. These lots are in grain rich areas like the Corn Belt and the High Plains from Texas to Colorado. Due to differences in activities and geographic separation, calf production and finishing have separate ownership. In 1993 there were 100 million beef cattle and calves in the U.S. (USDA, ERS 1993(b), Table 3).

On the range where brood cows are kept, it is impractical to monitor for estrus and inseminate artificially. As a result, only about 1.5 percent of beef cows are artificially inseminated (Gilliam 1984). The remainder are naturally bred by bulls purchased by the rancher for that purpose. Changing bulls is the easiest way a rancher can introduce new traits into the herd. The selection of bulls to run with the cows is therefore the breeding decision process and is made by each cow calf operator.[7] Often breeds are mixed to introduce desirable traits as well as "hybrid vigor".

A third segment of the sector is the production of (typically) purebred bulls for breeding. This component is extremely large and fragmented as firms specialize in one of the 70 or so breeds in common use. Aggregate numbers are not available, but as an indication, the Polled Hereford Breeding Association had in 1989 some 10,000 members.[8] Many of these operations are small and part time with some seemingly hobby-type activities.

Dairy Cattle: While biologically highly similar to beef cattle, the organizational aspects of dairying lead to very different practices. The milking herd must be bred annually so that

7 The choice is however a chancy one because the inheritance rate of some desirable traits like number born is low, about 5 percent (Acker 1983, Table 18-1).

8 Quoted in Lesser (1990), p. 88.

most dairymen produce their own replacements. That is, propagation and production are integrated in the same operation. Since cows are inspected at least twice daily during milking it is possible to detect estrus meaning artificial insemination is practical. Presently about 60 percent of dairy cows are artificially inseminated. Numbers of milking dairy cows were 10 million in 1992 (USDA 1992, Table 458).

Nationally there are four firms and affiliates which provide the majority of the semen. Production characteristics of the daughters of the bulls are described in catalogues which are used in selecting the donor bull. Bulls, used on the remaining 40 percent of cows, are typically sold locally, often by farms combining milk and sire production. These are abundant in number, with an estimated 20,000 in 1988 (Lesser 1990. Table 8). Dairy bulls are primarily purebreds, with Holsteins accounting for approximately 90 percent of the U.S. herd.

Hogs and Pigs: Pork production differs from beef in several ways due to biological differences. First, as non-ruminants, hogs and pigs are enclosed and fed throughout their lives. This makes it more feasible to combine propagation (farrowing) and feeding. In total three quarters of pigs are finished in integrated operations, the non-integrated operations being the smaller ones (Van Arsdall and Nelson 1984, Table 4). Second, sows are more fecund, producing annually an average of two litters of eight pigs each. This means breeding improvements can be introduced to the national herd more rapidly and quality breeding stock is proportionally of greater economic value. Yet artificial insemination use is still low, approximately two percent (Van Arsdall and Nelson 1984, Table 4). Hog and pig numbers are just over half of those for cattle, or 58 million in 1993 (USDA, ERS 1993(a), Table 26).

The sector producing breeding stock is bifurcated. About 20-25 percent of sows are bred to so-called synthetic-bred boars(Quoted in Lesser 1990, p. 88). Stated simply, synthetic breeding means the breeder owns multiple purebred lines which are crossed in complex patterns. By maintaining detailed performance records it is possible to produce more efficient breeding stock than would be possible with the small number of crosses made on individual farms. Internationally there are four firms which provide the bulk of synthetically-bred hogs.

Farms would typically buy both boars and sows but the former in greater numbers than the latter. Purebred boars used on the remaining farms are produced locally by multiple operations. There are no reliable estimates as to the number.

Laying Hens and Broilers: Large poultry operations are often combined with a hatchery, while smaller operators buy chicks from independent hatcheries. The input to the hatcheries is however all of the "synthetic" type as described above. Around the world there are about a dozen of these firms, but they tend to specialize in type (laying or broiler) and sex so that the number competing over each segment of the market is small – two or three in a few cases.

The U.S. laying flock averaged 278 million hens in 1992. The total number of broilers (meat type chickens) raised that year was 6.4 billion which translates to about 860 million broilers at any one time (USDA 1993(b), Tables 31 and 3).

Production

Beef Cattle: Most beef comes from cattle finished in feed lots. A portion - varying but around 15 percent – comes from grass fed animals and spent brood and dairy cows. Feedlot operators typically acquire their calves through specialized service operations known as dealers or commission agents. Those firms assemble and sort uniform lots from multiple cow-calf producers, which are on average very small. This means the feeder has no direct contact with the calf producer and relies to a degree on the judgment of the commission agent in selecting the calves.

Finished cattle are sold to packing plants, most commonly (85% by volume) in direct on-farm negotiated sales between the farmer and a packer buyer. Alternative sales arrangements, often used for small lots or older animals like brood cows or bulls, are buying stations, and auctions or terminal markets.

Dairy Cattle: In terms of livestock sales, dairy farms sell old cows from the milking herd as well as male (bob) calves. These sales are heavily concentrated in small local auction markets which are visited by packer buyers or agents representing them. Very little is known about the animals sold other than what is visible.

Hogs: Pork producers sell primarily barrows and gilts for slaughter. As with cattle, sales are predominantly direct to packers. Sows and boars which are older and somewhat less uniform may be sold at auction. Because most feeders breed and raise their own pigs, they would know a good deal about their genetic background. The U.S. Department of Agriculture recently began a hog tagging program so that the ownership of individual animals can be determined up to slaughter (USDA 1988).

Poultry: Spent laying hens are sold for soup stock production and similar uses. Broiler production however is quite distinct as most growers do not own the chicks. Chicks are provided with the farmer paid a service fee by the owner or "integrator", often a feed company (see e.g. Marion and Arthur 1973). Eleven major integrators provide the majority of broilers in the country. When fully grown the birds are shipped to a designated packing plant, possibly also owned by the integrator. Due to this vertical ownership structure the integrators have substantial control over the sector.

Synopsis

In terms of extremes, broiler production has the fewest independent owners. There are but a handful of breeders who sell to the 11 integrators who dominate broiler production in the U.S. As a result there is close coordination and control over ownership. Beef cattle present the opposite extreme with thousands of breeders, calf producers and feeders. Contact among these groups is typically only through market exchanges, and even then an intermediary may be involved. Any information about individual animals is virtually impossible to maintain in this environment. Hogs, dairy cattle and laying hens occupy different intermediary points between these two extremes. Any efficient royalty collection system must be adjusted to take account of these major differences across species and classes.

EVALUATION OF PROPOSALS

Before analyzing the three royalty collection proposals it is helpful to establish a scenario to examine. The one selected here is somewhat complex as it will involve **two** patented attributes which are held by different inventors but available in the same animal. While such an eventuality is admittedly somewhat distant it is fully likely in the livestock industry (and especially the long lived and low reproducing red meat species) where breeding is a cumulative process of adding improvements to the existing national herd. The two patented attributes made available by genetic manipulation/insertion assumed here are (a) increased production of bovine somatotropin (bST) for cattle or porcine somatotropin (pST) for pigs which enhances feed conversion efficiency leading to less fat in the carcass[9] and (b) higher birth weight, an assist to survival and faster weight gain. For simplicity we shall assume that enhanced bST/pST production is conferred by a single gene meaning that inheritability is 50 percent if one parent carries the trait and 100 percent if both do. Birth weight is controlled by multiple genes so that inheritability is less predictable. Studies on the outcomes of conventional selective breeding indicate that, when both parents have a disposition for this trait, inheritance is in the 5% (hogs) to 60% (dairy cattle) range (Acker 1983, Table 18-1).

The point of these examples is that the offspring of biogenetically altered animals will not necessarily inherit the trait. Yet the traits selected are economically desirable so that their absence will represent a loss to the farmer, making any animal not inheriting them less valuable. We now turn to evaluating the implications of the three proposals for royalty collection and their operation in regards to these two inventions.

Qualified Sales

This proposal was offered as an amendment to the U.S. Patent Act (35 U.S.C., sec. 1 *et*

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9 Preliminary studies have shown feed efficiency gains for hogs from 30 to 50 percent during the last 60 days (Etherton, *et al.* 1986; Boyd, *et al.* 1986) and up to 12 percent for cattle (Fabry, *et al.* 1985).

seq.) as a new Section 273[10]. In brief, the proposal operates as if there were no patents (a Qualified Sale) unless the patent holder specifically and formally declares an intention to collect royalties (and sue for infringement if they are not paid). No provisions are made for how the system would function for non-Qualified Sales.

More formally, the proposed legislation establishes a **voluntary** system of Qualified Sales under which the patent holder may authorize seller(s) to market animals for which the patent holder has waived the right to sue farmers for infringement. Under this legislation the breeder must be a person engaged in "farming" and the animals must be bred "conventionally" or through the use of sperm, eggs or embryos from a "transgenic farm animal". The latter term is defined as a "domesticated farm animal whose germ cells contain genes originally derived from an animal of another species". Unless otherwise specified, a sale shall be presumed to be Qualified. That is, specific notice is required if the patent holder intends to retain the rights to initiate infringement proceedings.

Initially, one can identify some probable definitional problems with the proposal. Perhaps most significant, the limitation of "transgenic" to genes originally derived from another animal species excludes work which could involve, say, a unique gene from within the same species, or genes not originating from higher animals or even from the animal kingdom. In addition, it should be noted that previous legislation which attempted to define "farmer" or "farming" raised significant legal problems.[11]

More substantively, the proposal essentially establishes a formalized means by which

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10 This proposal is not to be confused with the Transgenic Animal Patent Reform Act which died in Congress in 1989. That act simply banned infringement proceedings for transgenic farm animals except when sold in the form of germ cells, semen or embryos.

11 The Capper-Volstead Act grants limited antitrust exemptions to "persons engaged in the production of agricultural products as farmers . . ." (7 U.S.C. Sec. 291) to form cooperatives and the Plant Variety Protection Act permits individuals "whose primary farming occupation..." (7 U.S.C. Sec. 2544) is to save and sell on a noncommercial basis seed from protected varieties. Both definitions have been subject to rather unsatisfactory court review (*Case-Swayne Co., Inc. v. Sunkist Growers, Inc.* (389 U.S. 384 (1967); *Asgrow Seed Co. v. Kunkle Seed Col, Inc., et al.* (Appeal No. 87-1402 (Court of Appeals for the Federal Circuit)); and *National Broiler Marketing Association v. U. S. (Supreme Court, 1978)).*

the buyer/farmer is excused from royalty payments or other sanctions by the patent holder. No such formal action is required as the patent holder may simply not enforce his/her rights, but under these provisions the buyer is **assured** of protection from liability. Indeed, the patentee must specifically inform the buyer if the rights are to be enforced. Otherwise that right is forfeited. No provision is made for how the system would function if the Qualified Sales clause were not employed.

One needs to understand why the patentee would voluntarily waive his/her rights to collect royalties or otherwise control a wide range of uses of the invention. The only reasonable business explanation is that the inventor could earn equal or higher profits through the Qualified Sale process than without them. To understand that prospect let us consider how the proposed system would likely function.

Since the definition of "farming" excludes the production of reproductive materials, breeders would presumably not be considered to be farmers under this law.[12] Yet they provide key services and would have to be given a role – so they become the "authorized sellers". For the handful of synthetic hog and poultry breeders that would be a simple group to monitor; for the tens of thousands providing the remaining breeding stock, all but impossible. Thus a functional "Qualified Sales" system would seem to necessitate a major restructuring of segments of the breeding sector into a two-tiered system with authorized qualified sellers (presumably the large ones) handling transgenic animals and the remainder not. That enforced restructuring would have broad efficiency ramifications on livestock producers and is problematic.[13]

Yet even with the synthetic breeds the proposal is questionable. The trait-carrying brood animals would have a higher price needed to recover the R&D investment. The producer would

12 How the law would handle dual breeding and production operations such as for dairy bulls is not clear.

13 The use of fewer authorized sellers would also presumably minimize the complication of having a single animal contain one trait for which a firm is an authorized seller and another trait for which it is not.

be willing to pay this price only as long as it took to disseminate the trait in the herd.[14] Following that point, with the new genes well established in the herd, the benefits can be had without the expenditure of additional funds for the Qualified Sale animals. This dissemination could take as little as a few years in hogs, several more in the slower-reproducing cattle. All the R&D investment would have to be recouped in that brief period while the benefits would potentially be spread across decades. The more traits conferred by a single brood animal the greater would be the fee.[15] Would the livestock sector be willing and able, in effect, to pay up front for technological improvements? That is highly questionable in a low profit industry like livestock. Moreover, payment at the breeding stock level requires producers to accept all performance risk. If the offspring do not perform as well as expected, the producer, not the inventor, is the immediate loser. One risk which the producer will wish to avoid is the uncertainty that the brood animal is a trait carrier. This can be assumed only in the case of single gene traits (e.g. bST when both parents are carriers). In other instances (birth weight) testing will be required.

Registration

The registration system proposed by the American Farm Bureau Federation would use fees paid to Registry Associations (and forwarded to patent holders) in lieu of royalties. Thus the proposal, similarly to the Qualified Sale described above, effectively bypasses the patent system in favor of a fee placed on breeding stock. As the system presumes the trasgenic bred animals are purebreds, the Registry Associations would be affiliates of the existing Purebreed Associations which presently register (primarily) breeding stock for the red meat species. No

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14 The exception is with poultry for which the producer replaces the flock repeatedly through the regular purchase of both males and females from the breeder. With the red meat species the herd evolves with the introduction of new genetic material rather than being recreated.

15 Each inventor would presumably establish a fee (price) for breeding animals containing his/her gene(s). If several were contained in a single animal then the fees could be expected to be summed.

provisions are made for fee collections for non purebred breeding stock such as the "synthetics" described above.

The actual proposal would require farmers who purchase transgenic livestock "to register any animals sold for breeding purposes" or animals from which semen or embryos are sold. As with the preceding Qualified Sales proposal, animals used for production purposes would be exempt from payment. Animals for which a fee is paid will be registered and marked with a diode ear clip or similar device. To be eligible, "both parents must be registered as transgenic for the particular trait in question".

This proposal shares a major component with the preceding one, the payment of the royalty fee at the breeder sale rather than directly to patentees by individual farmers/producers. Presumably if this approach were adopted some legislation similar to the preceding would be needed to protect individual farmers from infringement charges, or a uniform contract specification to that effect be included (as suggested). This proposal would seem to be mandatory – mandating in effect compulsory licenses – which is objectionable to a segment of users and observers of the patent system. Mandating compliance does remove the case noted above where no provisions were made for when the "authorized seller" procedure was not selected. That is, a single system covers all cases.

As with the preceding proposal, this one has a similar limitation of requiring the payment be made "up front", before an income stream is generated by these new, more efficient animal strains. It does require both parents be trait carriers which for single gene-based traits (e.g., bST) assures the offspring be endowed also, but not otherwise. Thus in many instances the buyer would at minimum want a definitive test before paying the (considerable) fee.

From the perspective of the patent holder this proposal is somewhat less attractive than the preceding one. It is mandatory and involves Purebred Associations over which the patent holder has no direct control. (The preceding proposal allows the patentee to designate the "approved sellers".) With but one dominant dairy breed this is no great problem, but would be for the 70 or so cattle breeds.

The proposal acknowledges it is "not logistically possible to police a registry system" but suggests there are some incentives which would promote compliance. In addition to "pride and mystique," registered purebred buyers have some assurance of standard characteristics.[16] The registration fee for transgenic animals though could be many times that correctly charged by the Purebred Associations, presently as low as $35. Would it be paid? That is doubtful as tests would be required to determine if an individual carried a trait or traits. The test results would replace much of the product assurance value of the purebred designation so voluntary compliance would have to be considered unlikely wherever fee levels were high.

The proposal does suggest registered animals be pre-tested for the trait giving a better indication of value. However, that would not resolve the issue of payment collection from a commercial producer testing his/her animals and using or selling a trait bearing (but non purebred) one as breeding stock. The proposal does not appear to prohibit that option especially if only one parent is a transgenic. Yet in the bST example, half the offspring would have the trait.

The registration approach based as it is on purebreds does not seem to be feasible without some enforcement mechanism. The incentives for registration do not appear great enough to assure widespread compliance in the absence of a threat. Even then, purebred associations for some species are too numerous to monitor effectively while other trait-carrying but non-purebred stock can disseminate the transformed genes while falling outside the scope of the proposal. Moreover, Purebred Associations, some of which are in financial difficulty, would have to be convinved and compensated to take on the new role of fee collection.

Pooled Royalties

This is my own suggestion but one which does not exist in as detailed a form as the preceding two. What it is is a parallel between the problem of collecting royalties from songs

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16 The term "purebred" is rather imprecise but is taken to mean a group of individuals that share certain common characteristics like size, shape and coloration (Campbell and Lasley 1985, pp. 43-44).

played on juke boxes and the procedure used, known as a Tribunal (See Henn 1988, Chap. 23). The issues raised with juke boxes are their large numbers and broad geographic scattering. Moreover, the selection of songs is variable as would be the frequency with which they were played. A full accounting of plays, and hence royalties due to each artist/firm, would entail periodic tabulations of every machine. Clearly that is totally impractical. The alternative selected was to collect a fixed amount per play and distribute those proceeds according to the distribution of song selections from a **sample** of machines.

What does this have to do with patented livestock? Consider that the same basic issues arise. The patented traits (bST, birth weight and, over time, numerous others) will be dispersed in an unknown fashion across the one billion plus head livestock and poultry herd. Clearly, testing every individual and sending separate checks to each patentee would be wildly impractical. The first component of my approach then relies on a **sample** of animals. The distribution of the traits in the population will be assumed to be equivalent to that in the sample. Further work is needed on determining whether the sampling should be done on a regional basis or whether a national sample is sufficiently reflective.

Where will the sampling be done? Visiting a representative group of individual farms would be inordinately expensive. How much more efficient to sample where the animals are already assembled. And where is a more complete assembly accomplished than at the packing plants across the nation? Except for up to a 10 percent death loss and an additional 1-2 percent which are slaughtered outside the major plants and a very small number exported live, all livestock must eventually pass through licensed and inspected plants to be sold for human consumption.[17] The number of these plants is not great – a 1993 total of 1,090 for livestock and fewer for poultry (USDA, NASS 1993, p. 60). Even those figures overstate the number of plants which would need to be sampled for in 1985 17 plants slaughtered some 53 percent of

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17 These requirements are set forth in the Federal Meat Inspection Act of 1967 and the Poultry Products Inspection Act of 1968. Inspection for factors related to human health is performed at public expense by the Food Safety and Quality Service of the U.S. Department of Agriculture.

all cattle (Ward 1988, p. 5)[18]. Thus these plants are efficient places to sample the domestic herd. Packers also pay the sellers so that they would be well positioned to deduct funds based on the sample results and fees requested by patentees and send those royalties to the respective patent holders.

In brief then my proposal uses the meat packers to collect and disseminate royalties based on the distribution of patented traits in a sample of animals. The principal benefits of this approach are the minimization of the number of firms and paperwork needed. It also works equally well for any number of patented traits in the same animal, something which should be planned to occur at some future point. However probably the major benefit is the arrangement to collect royalties on **every animal carrying the trait and at the time of sale** rather than purchase so that additional working capital is not required. The packers will not be overjoyed by their expanded role and will require some financial compensation, which should come from the patent holders.

The plan would need to be mandatory, which will not be acceptable to some patentees who are strongly opposed to such compulsory licensing provisions for both ideological and financial reasons. One is sympathetic but, if royalties are collected at the end rather than the beginning (as with the previous proposals) of the production process, little opportunity exists for making individual royalty collection arrangements. It is simply too cumbersome and expensive. Second, the process will postpone royalty collection until after the production process is complete. This will delay the cash flow, a loss to inventors. Perhaps like pharmaceuticals, which typically take ten years to reach the market, patenting livestock will be limited to large, well financied corporations. Those matters aside, I see the major problems as (1) how the patentee prices his/her invention and (2) how, in the absence of individual tests at the time of purchase, the farmer is to know what he/she is buying.

The issues are related as, under this proposal, the farmer is buying something the

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18 In 1990 for cattle, 18 plants (1.6%) processed 500,000+ head annually while 793 plants (72%) handled under 1,000 head (USDA, NASS 1991, Table 25).

composition of which and hence price will not be known until the sale is made to the packing plant. Take, as a simple example, a hog farmer who buys two seemingly identical hogs, but one of which carries the parcone Somatotropin (pST) trait and one does not. Now assume the pST hog costs $10 less to feed than the other but the royalty payment, collected at time of slaughter, is also $10. Under these circumstances the farmer would be indifferent between the two. However, if the patentee charged a royalty of $15 one of the animals is of lower value than the other. Given a choice beforehand, the farmer would have purchased only non-trait carrying animals. But that was not known at the time so the traditional market mechanism based on informed choices and competition would not work.

The break down in the market mechanism is less complete for the producer (buyer) than for the inventor (seller). If the buyer is purchasing "large enough" quantities of animals then the distribution of the trait(s) within the purchased animals can be predicted with considerable accuracy.[19] The exact number of head needed to meet the "large enough" requirement is an empirical matter which must be determined on a case by case basis, but 100 is a good rule of thumb. What this says, quite simply, is that the large volume buyer can assume a 20 percent incidence of pST carrying animals in his/her purchases if the sample (taken at meat packing plants) is found to contain 20 percent pST carrying animals in the national herd. From this information, and a knowledge of how pST affects production costs, the producer can determine the value of the lot. This will be an additional hassle but not fundamentally different from the kinds of calculations made routinely today. Successful implementation assumes the trait composition in a species population remains relatively stable, say from the time a feeder calf is purchased to when it is sold to a packer, which could necessitate some adjustment of the population figures.[20] Small lot purchasers have a different problem for the likelihood of say ten

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19 Under the Central Limit Theorem, if the feeder calf population has a mean trait carrying level of 20% and a variance of 5, then the trait will be dispersed in the sample lot with a mean of 20 and a variance of 5/n, where n is the number of head purchased. See any introductory mathematical statistics or econometrics book (e.g., Kmenta 1971, p.107).

20 Populations, or traits within them, when left unchecked grow at an exponential rate. This means that if 10 percent of the adult population has the trait today, in six months to a

head having two (20%) pST carrying animals cannot be predicted with much accuracy. Thus this proposal will, if implemented, impose some disadvantage on smaller operations compared to larger ones.

The greater challenge is the pricing of individual traits by the patent holders whenever animals contain multiple traits. Let us say over time a species population comes to be 80 percent carriers of pST and 90 percent carriers of high birth weight genes. The problem arises with the minimum 70 percent of individuals which have both traits. Now assume each trait is worth $5 to the producer, or $10 in total. The careful and rational producer will be willing to pay no more than $7 ($10 x 70%) extra for a random individual. If the patent holders each ask five dollars for the traits, the purchase is unprofitable for the producer and will not be made. If both drop the price to $3.50, fine, but if one is adamant about the five dollar royalty then the other must charge two dollars for a sale to be made. The more traits contained in the herd and the greater the dispersion of productive value of those traits, the more complex is the problem of valuing individual traits.[21]

This is a problem of independent pricing by several patent holders of a joint product (the multiple trait-carrying animal). Each has an incentive to make the total product price low enough to encourage sales, but, with different cost and revenue functions, a market clearing

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year when the current feeder crop reaches market the proportion of trait-carriers could be considerably higher. The actual level will depend on a number of factors including the reproduction rate and numbers of brood animals held back vs. marketed and will be difficult to predict. Note however that this is not important for the integrated operations producing both feeders and market-ready animals. They will be paid for, and pay royalties on, the approximate composition of their herds. Those who purchase feeder stock also will generally benefit if the trait composition is higher than predicted by the national sample. They will pay royalties on the sample-projected trait composition. The loser could be the feeder producer who prices according to a predicted trait distribution which understates the actual. There are nonetheless reasons to believe the loss will be minimal in most cases provided that trait royalty is related to the production value (see discussion in text). If a trait does not become valuable until the feeding stage (e.g. pST), then the feeder price would be unaffected. On the other hand if the trait is useful to the feeder producer (e.g. heavier birth weights) the benefit is realized in terms of heavier weights sold. Thus the system would seem to accommodate some uncertainty about trait composition at the feeder level without major disruptions.

21 Especially difficult are the cases of interaction among the traits so that the value of XxY is greater (or less) than the value of X+Y. That case will not be considered here.

price may not be arrived at through independent price-setting activities. For this I see no solution but that some coordination body (perhaps the Tribunal) have the authority to intervene on royalty setting decisions. That is, prices must be set in relation to the market value of the cost reducing or price increasing effects of each invention. These effects can be determined experimentally, recognizing the value will vary with meat prices and feed costs. If the inventors cannot voluntarily reach a market clearing price then the Tribunal would have to intervene to make the necessary adjustments. Again, many inventors will be very upset with the prospect of losing control over pricing decisions, and perhaps that threat is all that is required to rationalize joint pricing, but some form of oversight seems essential.

SUMMARY AND CONCLUSIONS

The collection of royalties for patented livestock presents a major challenge for the patent system. On the one hand, the system is so immense and complex the organization of a system is conceptually and organizationally difficult while on the other, it is apparent some form of royalty payment is needed to sustain needed private investment in the production of improvements through genetic engineering. This paper analyzes three proposed systems, two of which collect royalties at the breeding level and one at the packer level. Two involve, in effect, compulsory licenses while the third is voluntary. Despite these strong and clear differences, two facets of this issue become abundantly clear. First, there is no ideal system identified to date; each has considerable limitations and costs. Second, it is essential that relatively simple, accurate and inexpensive tests be developed for determining the existence or not of traits in individual animals. It is not necessary or practical to test every animal, but some sample must be measured. If that is a slow and expensive proposition, administrative costs will absorb much of the potential benefits of the inventions and R&D will flag.

Among the three proposals, I favor least the one from the American Farm Bureau Federation. It has the key limitations of being both mandatory for breeding stock and operating at the breeder level. I do not believe it is viable to collect all the royalties from breeding stock;

since benefits will not be realized for several generations, the working capital requirements in a low profit industry are too great. Indeed, under this proposal, it is projected that "production" stock, for which royalties are not owed, will be used for breeding, further compressing the period for royalty collection. That is, the economic incentives established under this plan are not, in my judgment, great enough to engender voluntary compliance. The alternative breeder level proposal shares the key limitation of placing the payment burden before the productive merits of the inventions can be realized. It is voluntary from the perspective of the inventor, but no provisions are made for how non-participating inventors will be accommodated.

The third (my) system is quite different as it applies to the end of the production cycle when the livestock producer has realized the benefits of the inventions and can more readily pay for them. This is a benefit. The cost is the need for an elaborate system to determine what traits are in each animal and to collect the appropriate royalties. I set out a sampling system for doing this which, while plausible, is somewhat complex for producers, packers and inventors. Worse, the system imposes the equivalent of compulsory licenses and a system for "coordinating" royalty payments among numerous inventors. It might be noted that my system operates equally well for patented genes, which present a viable alternative to patenting animals, while the other two systems seem to be limited to patented animals only.

Once the intricacy of any of the royalty collection systems becomes known, that in itself could discourage private investment in improving livestock. That is most unfortunate for the need and potential both exist. Those who do become involved must, it would seem, accept some form of coordination of royalty collection. Such an approach may reduce profits below planned levels in some cases but, without it, the only real beneficiaries will be the collection agents. And that is no system at all.

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