Qualitative Veterinary Risk Assessment of the Spread of Bovine Tuberculosis Due to the Movement of Cattle

Introduction

1. Bovine tuberculosis (TB) is an infectious and contagious, mainly respiratory chronic disease of cattle caused by the bacterium *Mycobacterium bovis (M. bovis)*. Cattle are the natural host of bovine TB and they become infected when directly exposed to infected, infectious cattle (and their excretions), or other infected, infectious animals (and their excretions). Control of the disease in GB is complicated by a wildlife reservoir, which is geographically static in contrast to the movements of the commercially traded cattle host.
2. Therefore, uncontrolled movements of cattle may unwittingly introduce infection in TB-free herds. The movement of infected cattle between epidemiologically separate locations (***translocation***) is probably the main mechanism whereby bovine TB spreads from areas of high TB incidence to areas that are otherwise free from bovine TB. Depending on a number of host, environmental and, possibly, *M. bovis* strain-related (molecular) factors, bought-in ("translocated") infected cattle can amplify the infection in the herds and areas of destination more or less efficiently resulting in within- and between-herd ***spread***. If this spread into low incidence areas is not checked, it may eventually lead to the establishment of new TB "***hotspots***" in areas previously considered free from the disease. Once established, these hotspots can be very difficult to eliminate, particularly if the infection spills over into wildlife hosts that are capable of acting as alternative reservoirs of infection.
3. This veterinary risk assessment describes and ranks disease management options to reduce the impact of the movement of cattle infected with bovine TB. **The risk addressed here is solely that associated with the movement of bovines to a epidemiologically separate location of similar or different TB risk status**.
4. In this context, the herd level of risk is defined as high or low depending on the frequency of tuberculin testing required – high risk herds are those subject to annual or two-yearly testing, and low risk herds are those tested every three or four years. The concept of cattle movement along a "disease risk gradient" e.g. movement from high risk to low risk herds, is useful in understanding the potential impact of individual movements. Even when movement is up the risk gradient i.e. from a low risk herd to a high risk herd, there still remains a possibility of introducing infection. However, it is arguable that the epidemiological consequences are less for a high-risk herd than a low-risk herd.

5. **Note: It is not possible for the current testing technology to detect 100% of *M. bovis*-infected cattle. Therefore, the movement of any cattle from one premises to another, irrespective of testing being carried out, carries an unavoidable risk of translocating infection as a result of infection failing to be disclosed in a small proportion infected cattle.**

Risk question addressed in this document

6. **"What are the most effective management options for reducing the likelihood of new incidents of bTB arising from the movement of cattle between herds?"**

Summary of major risks

7. **(1) Undetected infection due to:**

   (a) Failure to submit an infected bovine to testing due to:

   - Exclusion from testing requirements e.g. due to age, recent testing (within 60 days), origin in low risk herd (figure 1, arrow 1) or by moving animals between premises at intervals of 30 days or less, or
   - Non-compliance by the farmer (figure 1, arrow 5).

8. **(2) Failure of the testing procedure to identify a true positive (figure 1, arrow 1)** in the herd of origin can be attributed to any one of the following:

   (a) **The test characteristics -** the inherent performance limitations of the test - due to the sensitivity characteristics of the test (ability to detect a truly infected individual). This ranges from approximately 50% to close to 100%, but with a median sensitivity from reported studies of 80% at the animal level. The implication of this is that two in every ten infected bovines presented for testing are likely to be missed.

   (b) **The test procedure** - being carried out incorrectly.

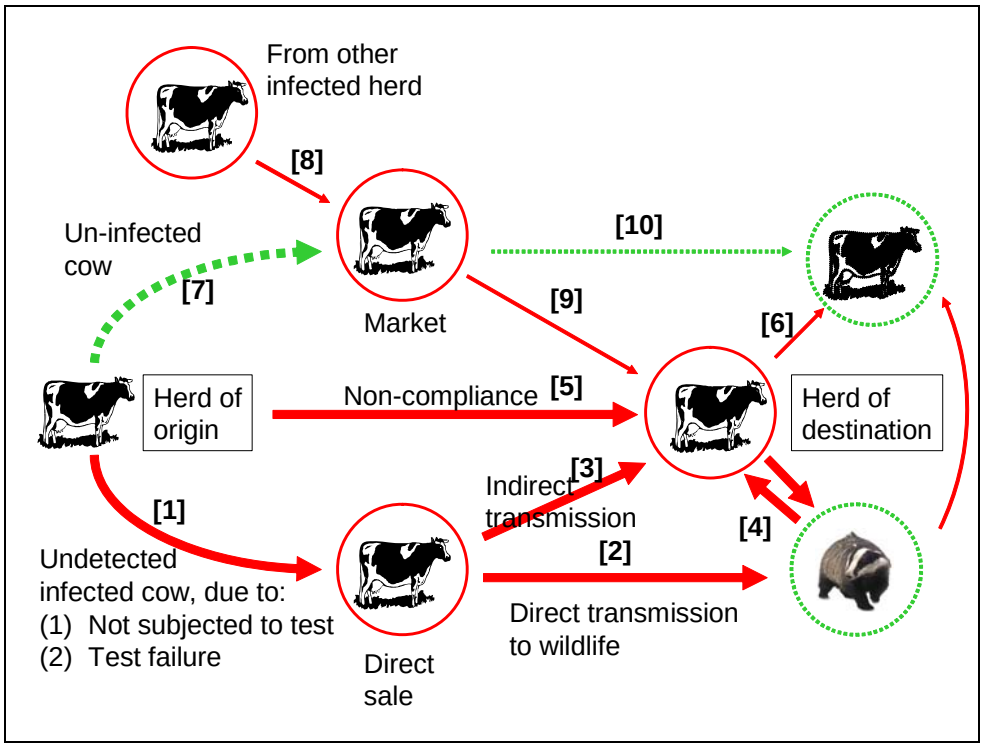
   (c) **The test reagents -** being insufficiently antigenic, due to poor production/standardisation or storage etc.

   (d) **The physiology of the individual bovine subjected to the test -** the test is carried out at a time when the individual animal is unresponsive or has a reduced response to the skin test – this could be due to (1) recent infection, for example half of all animals infected 30 days prior to the test may be unresponsive, (2) skin testing less than 60 days before the present test, or (3) natural variation in the immune response of the individual bovine e.g. due to inter-current disease, physiology (e.g. pregnancy) or very advanced disease (anergy).

9. **(3) Contact with infection in the marketing chain** post-testing (figure 1, arrow 8) - by direct contact with an infectious bovine, although pre-moment testing would reduce the number of infectious bovines in the marketing chain.

10. **(4) Direct contact with undisclosed infection** in the herds of origin or destination, other herds or wildlife adjacent to either of these (figure 1, arrows 6 and 4). Transfer of infection by direct contact (with both cattle and badgers) in or adjacent to the herd of origin, in the marketing chain and the herd of destination.

Figure 1: Movement of bovine TB infection
(Note: Only the most relevant risk pathways are illustrated in this figure)



Summary of risk management options

11. The elements from which to formulate a risk management strategy for reducing the bovine TB-related impact of cattle movement, and from which to construct the control options are:

    (a) **Classification of herds according to risk** – in order to manage the level of risk, the level of risk must first be determined. (N.B. for this purpose high risk farms / areas are defined as those under 1 or 2 year testing regimes, and low risk are those under 3 or 4 year testing regimes. The frequency of herd testing frequencies is generally determined according to historical data on confirmed TB breakdowns in the parish. In addition, individual herds posing a high animal health risk in 3 and 4 yearly testing parishes can be placed under a more stringent testing regime.)

    (b) **Methods to restrict the movement of cattle** - including zoning, channelling to more bio-secure centres (e.g. TB finishing units, possibly including fully integrated calf rearing units) and then only to slaughter.

    (c) **Testing of cattle being moved, including the timing of such testing** - either pre- and/or post-movement.

12. The risk management options are ranked in descending order of likely effectiveness. Those described by Madders *et al* , are included in the list below and denoted by the option number from the report.

MOVEMENT RESTRICTIONS

(a) **<u>Stop all movements</u>** of cattle (this was not listed by Madders *et al)*.

(b) **Option 7:** <u>Zoning</u>: i.e. banning of all movement of cattle from areas of high TB incidence to areas of low TB incidence, without some form of risk assessment and assurance testing.

(c) **Banning all movement from restricted herds, except direct movements to slaughter or to approved finishing units –** this is already standard practice.

TESTING *(note: options are numbered according to the order used in the Regulatory Impact Assessment)*

(a) **Option 1:** Do nothing, i.e. no statutory requirement for pre or post-movement testing

(b) **Option 2:** Pre-movement testing for all cattle moving from 1 and 2 year testing herds to any other herd (with exemptions)

(c) **Option 3:** Post-movement testing for all cattle moving from 1 and 2 year testing herds to 3 and 4 year testing herds

(d) **Option 4:** Pre-movement testing for all cattle moving from 1 and 2 year testing herds and subsequent post-movement testing at all 3 and 4 year testing herds

(e) **Option 5:** Pre- and post-movement testing of all cattle sold for breeding and production regardless of herd of origin and destination

(f) **Option 6:** A pre-movement testing system based upon the herd TB history, i.e. cattle to be tested that come from herd that have experienced a confirmed breakdown in the past five years

(g) **Option 8:** Pre-movement testing for all cattle over 15 months moving from 1 and 2 year testing herds to any other herds (with exemptions) – this is the policy in force as at November 2006.

Discussion of risk management options:

13. Note: The imperfect sensitivity of all the tests currently available for ante-mortem diagnosis of bovine TB may result in failure to detect all infected animals in a group of cattle during a single pre- or post-movement testing event. Therefore, veterinary advice is that the most effective management options are those related to cattle movement controls. Using both the tuberculin skin test and the γ-interferon test in parallel (i.e. consider the test result to be positive if cattle react to *either* test) would improve the sensitivity of pre- or post-movement testing, but this would be at the expense of declaring more false positives and a more complex testing protocol, which might render such option cost-ineffective.

(a) <u>Classification of all herds according to risk</u> - which herds should the requirement for testing be applied to?

14. Modelling carried out at VLA indicated that the most important factors affecting the probability that a move to an epidemiologically separate location will be followed by a TB incident are, in decreasing order of magnitude:

- local incidence around the destination,
- size and type of the destination herd,
- incidence of animals with visible TB lesions (VL) in the source herd in the past 5 years,
- local incidence of VL animals around the source herd.

15. The third factor is considered the main indicator of infective cattle movements and, unless the incident can be directly attributed to recent purchase of cattle, then efforts should be concentrated here. It follows that there is potentially less to be gained from requiring pre- or post-movement testing between herds in high TB incidence areas, since there is a pre-existing risk of an incident in the herd of destination from exogenous infection in the locality (from neighbouring cattle herds or wildlife).
16. The process could be refined by considering the effect of the fourth factor: it is likely that the local incidence around the source herd is a proxy for wildlife infection and while the herd from which the animals are to be moved may have several years of a clear testing history there is strong probability that it will be a source of VL reactors if the herds around it have a poor TB history.

(b) Testing - when should the test take place, before or after the movement, and what is the window for permitted trade?

17. Infection can take place at any time, and the risk of this is highest for cattle in 1-2 year testing herds, where there is likely to be a high prevalence of infection or a considerable risk of introduction between routine tests. The traditional view has been that the skin test is unable to detect infection reliably until 42 days post-exposure, although recent experimental research shows that there is a degree of random variation, with some cattle becoming reactors as early as 3 weeks after exposure. In practice, a 60-day interval is allowed in Great Britain between two consecutive skin tests and between removal of infected cattle and the next skin test. Thus, even under ideal conditions there is potentially a 60-day window for infection to be present when it may not be detected by testing. Furthermore, cattle cannot be tuberculin tested for up to 60 days after injection of tuberculin, due to desensitisation of the skin and the conditions of usage in the tuberculin datasheet. Cattle can thus be infected if not properly isolated during that period. This should not be ignored in the context of the risk posed by movement from a high risk herd with a system of pre-movement testing.
18. It is important to note that in the case of low risk (3-4 year testing) herds importing cattle from high risk (1-2 year testing) herds, any failure in the testing system is significant as it may not be detected until the next routine herd test. In the worst case, if the destination herd was tested immediately prior to the import, the next routine test may not be for another four years, with serious implications for the potential for disease spread both within and beyond the herd.
19. Field data, based on the testing procedures for imported Irish cattle, suggests that pre- and post-movement testing are of broadly similar efficacy in detecting reactors, but that is predicated on the premise that the efficiency of testing is similar in both instances. This is currently the best available source of data and thus, in terms of sensitivity (ability to detect infected animals) **a combination of both pre- and post-movement testing provides the best protection against translocation of infected cattle**.

20. **Pre-movement testing** on the farm of origin alone entails some risks in terms of detecting infected cattle:

    - cattle may be incubating disease at time of test, but have not yet developed a reaction to tuberculin (generally this takes 3-6 weeks after exposure); and
    - animals may become infected subsequent to pre-movement testing, either in the period between testing and departure from their home premises or during transit (which may be via market and dealers' premises).

21. Therefore, with pre-movement testing, markets are an issue because pre-movement tested cattle should not be mixed with cattle from high risk herds that have not recently been tested (i.e. of lower status). Either markets should be avoided altogether or a complex system of market approvals with separation (in time and/or space) of different categories of cattle according to testing status may be necessary.

22. **Post-movement** testing 60-120 days after arrival on the destination farm circumvents the problem of animals becoming infected during transit or immediately before/after pre-movement testing. It is, however, more difficult to enforce and logistically organise (e.g. there is a need to guarantee post-movement isolation to preserve the officially TB-free status of the destination herd). It also lacks the advantage of containing infection at source. For these reasons, post-movement testing on its own is less likely to prevent a further bTB incident, with the subsequent additional expense to purchaser and taxpayer and associated risks of creating a new bTB hotspot).

(c) Purpose - can the test be applied to a particular (age) class or classes of cattle only?

23. There is no basis for disregarding any animals which are likely to remain in a destination herd for any length of time, even those which are being fattened for slaughter. Any infected animal moving to an area without a history of TB incidents could potentially, irrespective of whether it establishes infection in the herd of destination, infect the local wildlife and, therefore, represents a risk of terms of starting a new 'TB hotspot'.

24. For the sake of simplicity, one can assume that the risk of translocating bovine TB by cattle (of any given age cohort) moving out of herds subject to annual or biennial testing is a function of four main variables:

    - The prevalence of infection in that age group
    - The volume of farm-to-farm or farm-market-farm movements in that group
    - The types of herds receiving such movements
    - The time spent by the moved cattle in such herds until slaughtered or disclosed by TB testing.

25. Cattle of any age, including newborn calves, can succumb to *M. bovis* infection by the pulmonary or oral routes (congenital infection of calves *in utero*, although possible, is considered extremely rare in GB and other countries with long-established test and slaughter regimes). Age in itself does not appear to affect the susceptibility of cattle to the bacillus. However, the opportunities for exposure to the bacterium increase with time and, once infected, cattle are believed to remain sensitised to bovine tuberculin for the rest of their lives. In addition, the older the cattle the greater the chances that they are being kept for breeding and being subject to at least one tuberculin skin test. Therefore, there is a cumulative age-dependent risk of becoming a test reactor. A

reasonable estimator of the prevalence of infection in a group of cattle at the time of testing is the number of tuberculin test reactors relative to the number of animals tested in that group. This is better than looking at absolute numbers of reactors per age group because it takes into account the increasing likelihood of having a test as the animal grows older. Data on the age-specific incidence of tuberculin reactors calculated from all cattle tests recorded on VeBus (approx. 50% of all cattle tested in GB) in 2004 and 2005 show a steadily rising incidence throughout the first 24 months of life, followed by a more or less stable incidence rate for older cattle (**Figures 2a and 2b**).

Figure 2a –Age-specific incidence of skin test reactors (by year of age at time of test)

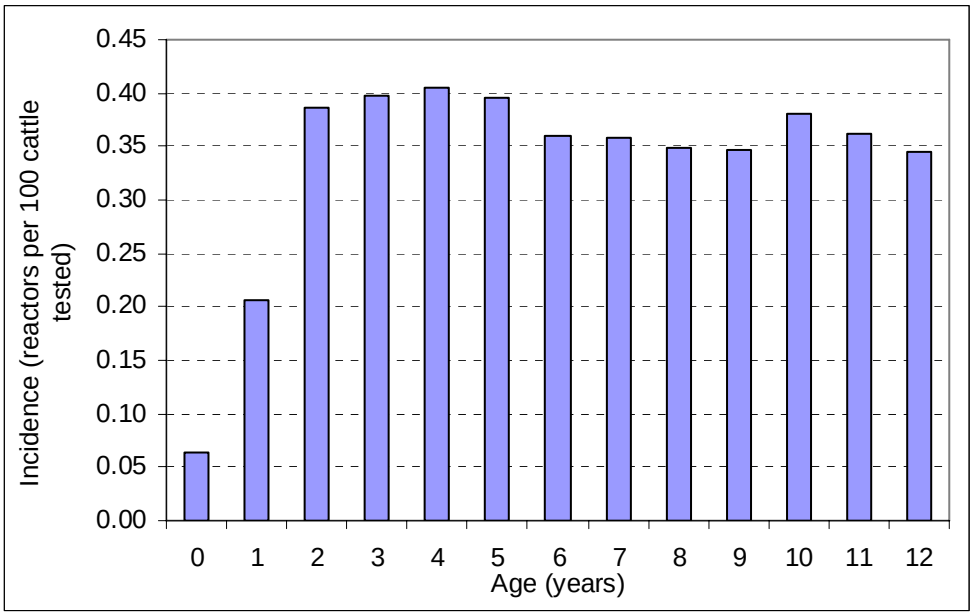
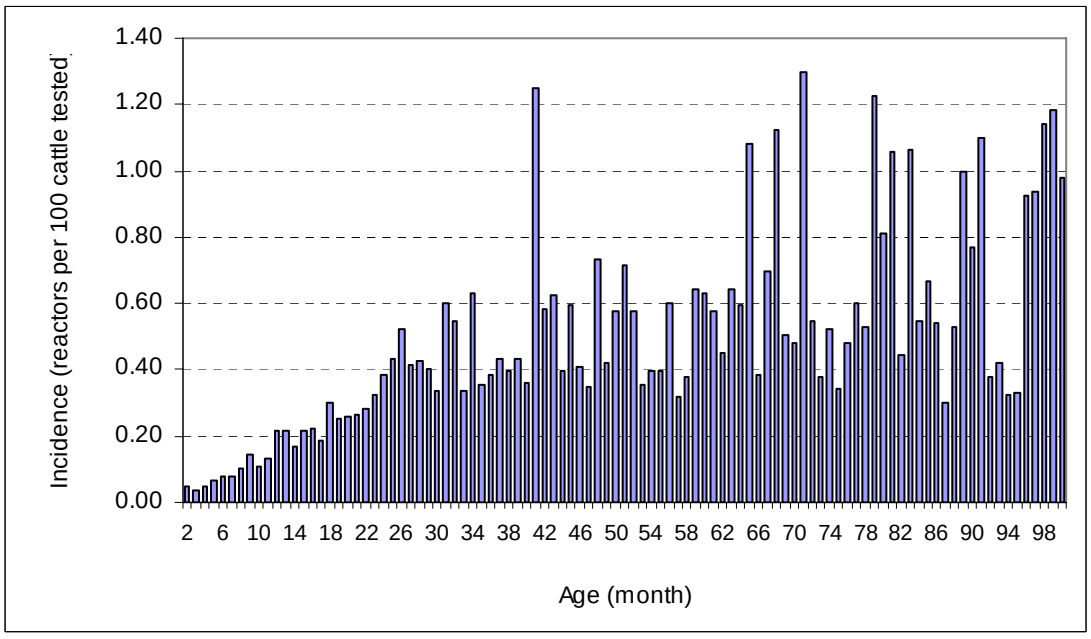


Figure 2b – Age-specific incidence of skin test reactors (by month of age at time of test)



26. As part of the review of Phase 1 of pre-movement testing, VLA interrogated the CTS database to determine the numbers of cattle in different age categories moving out of 1 and 2 yearly tested herds in England between January 2004 and mid-August 2006 (i.e. a period spanning the introduction of the new policy). **Figure 3** below shows that:

- As expected, the total number of cattle movements were far greater in the >15 month category than in the younger categories.
- The majority of movements in the >15 month category were direct to slaughter or were otherwise exempt from pre-movement testing.
- Substantial numbers of cattle avoided pre-movement testing thanks to the 30-day residence exemption, although the numbers have not increased relative to 2004 and 2005.
- Cattle owners are making use of the 60-day exemption and moving more animals after a negative herd test than they were before the introduction of pre-movement testing.
- The majority of movements of cattle aged 6 weeks to 15 months over the period of the analysis were movements to other herds, i.e. they would have qualified for pre-movement testing had the 15-month exemption not been in place. Movements to slaughter represent a small proportion of the total. As a result, the number of potentially eligible movements in this category was just below that for all the older cattle. In fact, since the introduction of pre-movement testing, more cattle aged 6 weeks to 15 months have moved out of high risk herds to other herds than cattle over 15 months of age. In other words, a large number of cattle out of high TB risk herds have been avoiding pre-movement testing simply by virtue of their age.
- the overall pattern and volume of eligible movements in 2006 for cattle under 15 months of age has so far remained consistent with previous years, with seasonal peaks in April-May and October-November. For the >15 month category in 2006, however, the volume of movements before the introduction of pre-movement testing consistently exceeded those of January-March 2004 and 2005, but this was followed by a big drop after the implementation of pre-movement testing.

Figure 3 – Monthly numbers of pre-movement tuberculin testing (PrMT)-eligible and exempt movements of cattle over the period 1st January 2004-14 August 2006, for different age categories.

Note: the charts represent the total monthly cattle movements out of annually or biennially tested herds (CPH) in England to other herds (CPH) in England, Scotland or Wales, for three mutually exclusive age categories. Each bar is split to show the proportions of PrMT-eligible movements against those exempt from PrMT (e.g. movements to a slaughterhouse,a showground, where the cattle had been on the premises for less than 30 days or where the cattle had been tuberculin tested in the previous 60 days with negative results). Farm-to-farm movements via markets have been merged with direct farm to farm moves so that, if qualifying under the PrMT criteria, they would be subject to just one PrMT test.

Figure 3a – Cattle under 6 weeks of age:

- Total movements not to slaughter: 407,041, split as follows:
    - movements that could have qualified over the period, assuming such young cattle were to be subjected to PrMT: 61,018 (10,417 between 1 April and 14 August 2006)
    - movements within 60 days of a negative test: 3,190
    - movements where cattle were on the premises of origin for <30 days: 342,833
- Total direct movements to slaughter: 95,393

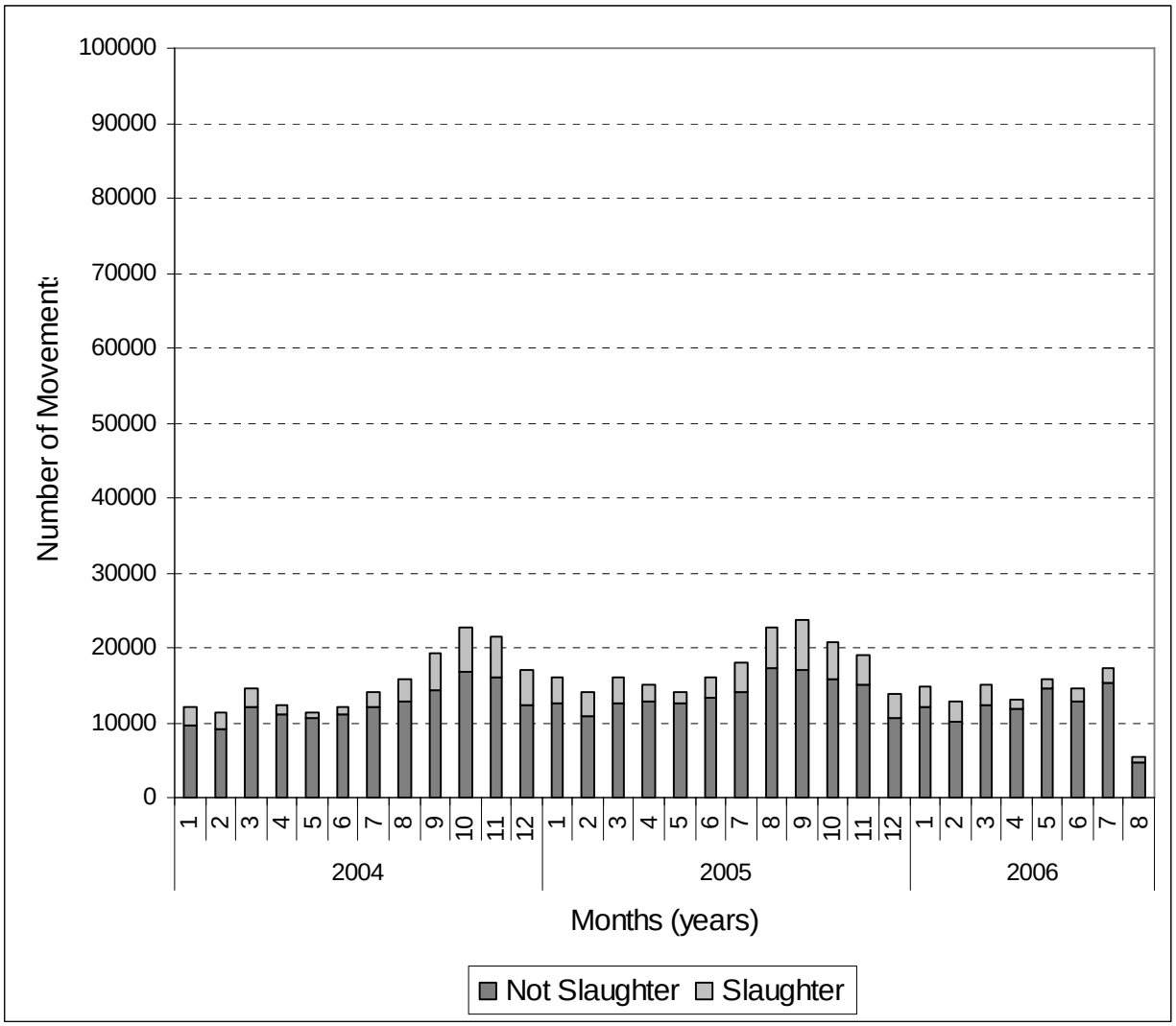


Figure 3b – Cattle between 6 weeks and 15 months of age:

- Total movements that could have been eligible for PrMT over the period: 628,555 (94,065 between 1 April and 14 August 2006)
- Total movements within 60 days of a negative test: 59,130
- Total movements where cattle were on the premises of origin for <30 days: 69,832
- Total direct movements to slaughter: 108,951

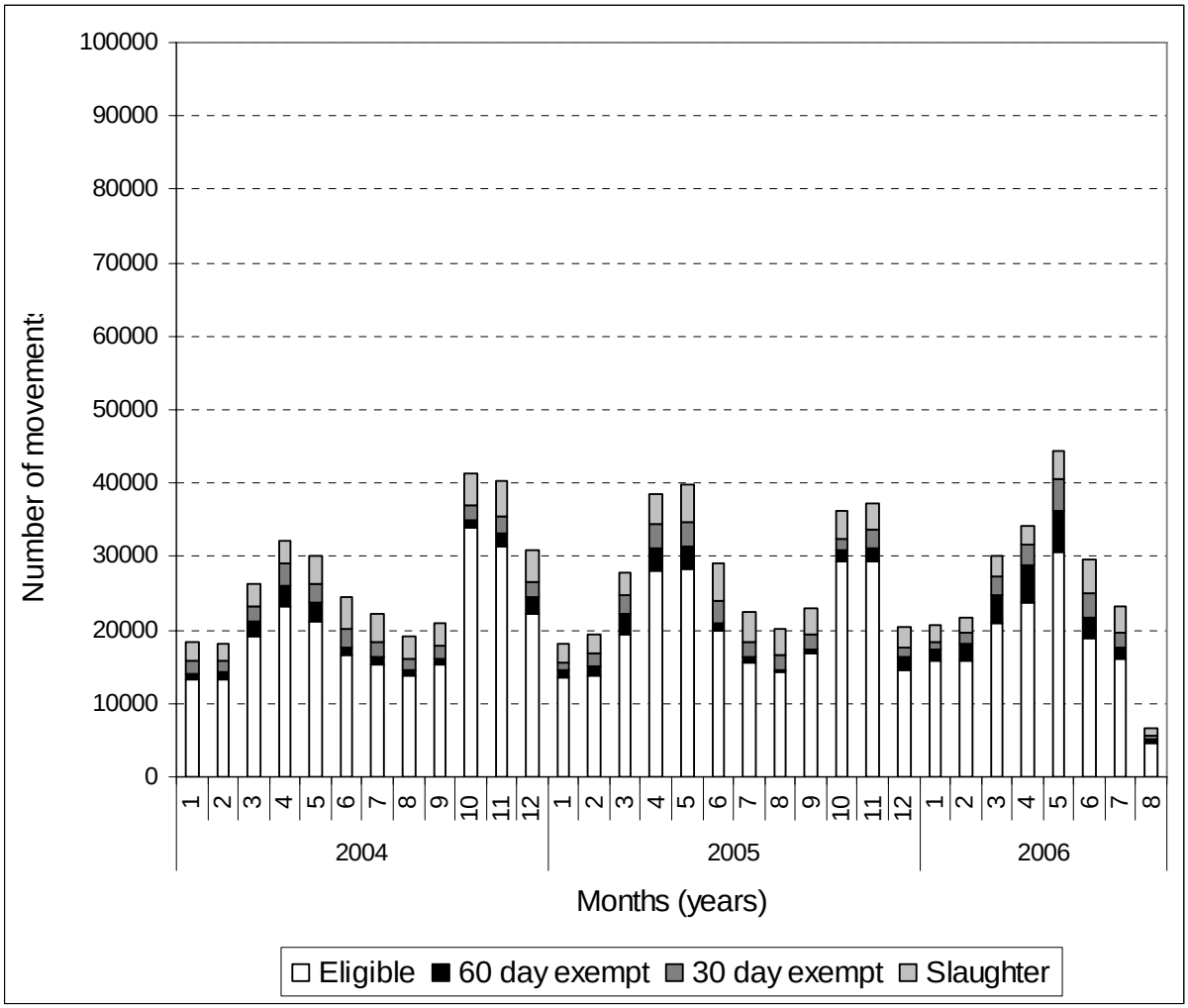
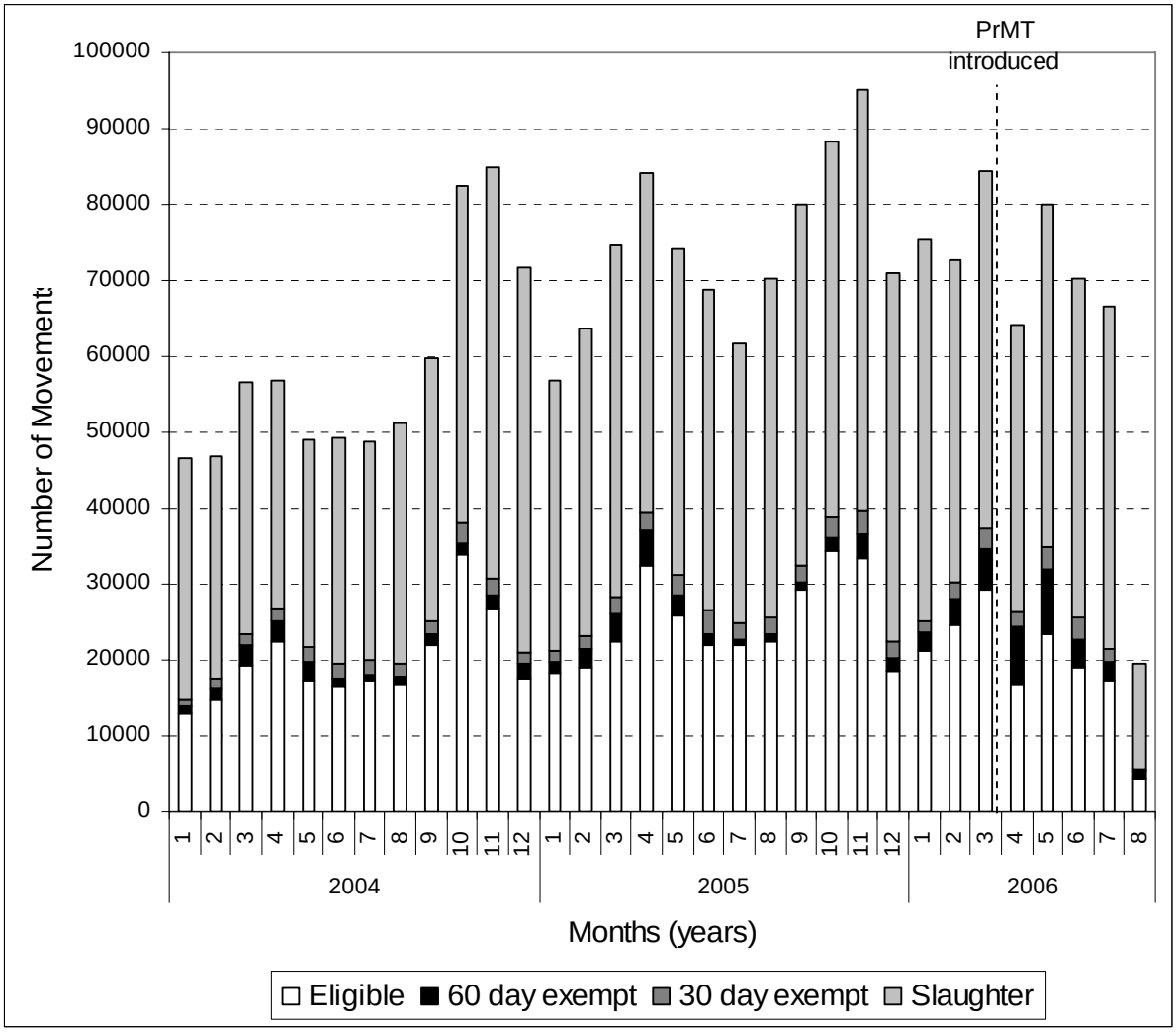


Figure 3c – Cattle over 15 months of age:

- Total movements that were eligible for PrMT over the period: 694,047 (80,739 between 1 April and 14 August 2006)
- Total movements within 60 days of a negative test (currently exempt): 78,914

- Total movements where cattle were on the premises of origin for <30 days (currently exempt): 65,769
- Totaldirect movements to slaughter (currently exempt): 1,286,532



27. In summary, TB is commoner in older cattle, but the rate at which younger animals react to the skin test is still considerable and cannot be ignored. In addition, the volume of cattle moving between farms at an age ranging from 6 weeks to 15 months old is nearly as large as the total for cattle over 15 months old. This high volume of movements of young cattle compensates for their lower incidence of infection. Once infected, cattle under 15 months of age are as likely to carry the infection to non-infected herds as the older cattle. A recent review of 31 herd breakdowns in the Northeast of England occurring between January 2002 and June 2004 showed that on several occasions this was due to the movement of cattle in the 6 week to 15 month age range (Gopal et al., Veterinary Record 2006). In fact, in 19 of these herds the age of the animals translocating bTB could be determined. In 11 of the herds they were 12 months old or less and in 8 herds they were over 12 months.

28. In light of all the above, veterinary advice is that **all cattle from eligible herds should be subjected to pre-movement testing as soon as they are of an age able to respond to the tuberculin test**. Current practice in GB and international convention (e.g. live cattle exports within the EU) is that routine TB testing programmes should commence from 42 days of age.

29. The issue here is not whether pre- or post-movement testing of all cattle above 42 days of age before they move out of 1- and 2-yearly tested herds is an effective TB control measure. Removing the current age exemption for cattle under 15 months of age will certainly detect additional infected animals that would otherwise continue to be missed, thus preventing new TB incidents in the herds of destination and resulting in earlier disclosure of infection in the herds of origin. The question is whether or not this is a **cost-effective** measure, i.e. will the undeniable benefits of pre-movement testing (and detecting) extra infected cattle between 42 days and 15 months of age outweigh the additional costs incurred by farmers in 1- and 2-yearly testing areas?

(d) Restrictions on the movement of cattle - including marketing through bio-secure, approved TB finishing units and then only to slaughter.

30. This would involve direct sale to approved, secure TB finishing units. This channelling also permits improved targeted surveillance at post-mortem inspection. Such units could be fully compartmentalised, integrated production systems from calf to slaughter.

Recommended action

31. The veterinary advice on the most effective management options for reducing the likelihood of new incidents of bovine TB arising from the movement of cattle between herds is as follows:

- The current tests available are insufficiently sensitive to eliminate the risk of spreading TB through the movement of cattle. The only effective risk management measures are based on strict movement controls:
    a. Zoning - ban all movement from high risk areas to low risk areas, except for movement to special TB finishing units (which should be subjected to heightened levels of post-mortem inspection).
- If such movement control is not possible, both pre- and post-movement testing should be applied to cattle meeting the following criteria:
    a. Originating in “high risk” (1 and 2-yearly testing) herds;
    b. Moving more than 60 days after their last clear test. There is no veterinary justification for extending the inter-testing interval beyond 60 days;
    c. Moving to other herds, regardless of the TB testing frequency in the herd of destination;
    d. As soon as they are able to be detected by the intradermal tuberculin test if infected *in utero* or immediately after calving, i.e. cattle from 42 days of age.

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