Body Condition Scoring (BCS) - Exposing the Myth

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This paper challenges one of the fundamental assumptions that currently underpin many animal welfare prosecutions in the UK. It critically examines the flawed assumptions and unscientific methodologies that suggest that Body Condition Scoring (BCS) is a reliable index of animal suffering. It analyses the definition, history and validation of BCS as a measure of body composition; considers the scientific literature relating to starvation and rehabilitation in both animals and humans; and argues that many previous cases based on the flawed use of BCS may have led to multiple miscarriages of justice. It argues that it is time for a fundamental re-examination of the way BCS evidence is used in animal cruelty prosecutions and assessed by the courts. The author is a leading specialist in the field of defending animal welfare prosecutions brought by the Royal Society for the Prevention of Cruelty to Animals (RSPCA).

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In the animal kingdom, one size does not fit all. Diversity is the norm; even within a species. Evolution, which works by trying new variants, has ensured that each individual is different. As such animal growth rates, build, and body composition can vary greatly between animals; even between sibling animals.

This normal variation is described by statisticians as the Normal Distribution, and is used to estimate the range that about 95% of any population falls into. Think of height. There are tall people and short people, but most people would not be described as either unusually tall or short. Extremes outside the normal range naturally occur. The same can be said about weight, build and body composition. Just because an animal's physical appearance is outside the normal range does not mean that it is abnormal for that individual animal or, ipso facto, suffering.

Yet where animals, which show no signs of disease, have been assessed as having a low body condition score[1] (a subjective approximation of an animal's energy reserves) by an RSPCA-instructed vet, their owners all-too-frequently face criminal allegations that they have "starved" or "underfed" their animals. Similarly, owners of animals considered small for their age are sometimes accused of causing their growth to be stunted by underfeeding the animal when it was young.

Counter-intuitively, allegations of causing suffering can occur even when the animal is described as being bright and alert, and as having normal vital signs; or when photographs and videos of the animal appear to contradict or undermine the assessment made by the prosecution's vet.

[1] Often described on a scale of 1-9 or 1-5.

Criminal prosecutions brought by the RSPCA usually involve somewhat vague charges that the owner has caused the animal to suffer[2] by either "failing to provide it with a nutritionally balanced diet", or by "failing to investigate and address" the cause of its allegedly poor body condition.

The legal consequences arising from such charges can be severe. On conviction, pet owners currently face a sentence of up to six months imprisonment[3] (although this is likely to rise to 5 years under proposed legislation); they may also be disqualified from owning, keeping, or dealing with animals for life; and/or be ordered to pay the RSPCA claimed costs which can run into tens or even hundreds of thousands of pounds. In some cases, this has enabled the RSPCA to register a charge against a defendant's home in order to recover those costs, together with interest.

Body Condition Scoring (BCS) was originally developed as a rough and ready field tool to periodically evaluate livestock feeding programmes. It requires the evaluator to appraise the animal (or a random sample from a herd or flock) both visually and by palpation, and then to assign a BCS to indicate whether nutrition should be increased, decreased or remain the same. The aim being to put animals into optimal condition for production.[4] What is considered optimal may vary depending on the time of year or the stage reached in the animal husbandry process. In other words, BCS was designed as a subjective, semi-quantitive gauge of an animal's energy reserves for reproduction or relative to meat, milk or egg production. Subsequently, BCS systems (which are species, breed, and often sex specific) have been applied to a wide range of animals, including pets.

BCS has not been validated as a measure of suffering, muscle loss[5], or the actual body composition of an animal, yet prosecutions are based on the claim that any animal in BCS 1 is utilising vital muscle mass to survive and is therefore in a suffering state. However, such claims are forensically and scientifically unsound.

In cats and dogs, BCS systems were first developed by pet nutrition company Purina, primarily as a practical tool to help tackle obesity in adult animals. However, validating studies were skewed towards assessing fatter cats and dogs, with animals at the lower end of the BCS spectrum being absent or underrepresented in the studies.[6] As such the scientific foundation of BCS use in criminal trials as a measure of "suffering" is gravely flawed.

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[2] Contrary to S.4 Animal Welfare Act 2006. Alternatively owners may be charged with an offence of failing to meet the animals needs for a suitable diet contrary to section 9 of the Act.

[3] See S.32 Animal Welfare Act 2006.

[4] See for example: Wildman, E. E., G. M. Jones, P. E. Wagner, R. L. Boman, H. F. Troutt, and T. N. Lesch. 1982. A dairy cow body condition scoring system and its relationship to selected production characteristics. J. Dairy Sci. 65:495.; S.T. Morris, P.R. Kenyon and D.L. Burnham (2002) A comparison of two scales of body condition scoring in Hereford x Friesian beef breeding cows. In Proceedings of the New Zealand Grassland Association 64: 121–123. In beef cows it is suggested that body condition should be evaluated and recorded three times a year: at weaning, 60-90 days before calving, and at calving. See: https://pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/400/400-795/400-795_pdf.pdf

[5] Tarkosova D, Story MM, Rand JS, et al. (2016) Feline obesity – prevalence, risk factors, pathogenesis, associated conditions and assessment: a review. Vet Med - Czech 61, 295–307.

[6] European Pet Food Industry Federation's (FEDIAF) 2016 nutritional guidelines. Citing: Laflamme D. Development and validation of a body condition score system for cats: A clinical tool. Feline Practice 1997a; 25 (5-6): 13-18.; Laflamme D. Development and validation of a body condition score system for dogs. Canine Practice 1997b; 22 (4): 10-15.; Mawby DI, Bartges JW, d'Avignon A, et al. Comparison of various methods for estimating body fat in dogs. JAAHA 2004; 40: 109-114.; Bjornvad CR, Nielsen DH, Armstrong PJ, et al. Evaluation of a nine-point body condition scoring system in physically inactive pet cats. Am J Vet Res 2011; 72 (4): 433-437.

Notwithstanding this, the RSPCA frequently bring cruelty prosecutions based on assertions that any animal (including juvenile animals) adjudged to be in BCS 1, and/or weighing 20% less than its so-called ideal weight, has been caused to suffer due to emaciation.

The basis for these assertions can be traced to a work entitled "Veterinary Forensics: Animal Cruelty Investigations" 2nd Edition (2012), by Melinda D Merck DVM; a book which was described as "a veterinary bible" by one respected prosecution vet during his evidence in a recent criminal trial. Yet some of the claims contained in this work are at best contentious – and at worst, fallacious.

Merck states that:

> "An animal is emaciated if it has experienced a minimum 20% tissue weight loss from its ideal body condition."

The problems with this broad assertion are manifest.

Normal Distribution tells us that 96% of the population are plus or minus 2 standard deviations from the average. As such, the expectation is that 95% of the relevant animal population are within 20% of the average weight. If an animal is outside of that range, as we expect about 1 in 20 (5%) to be, there could be a number of reasons, including natural variation.

However, in order to assess weight loss, Merck advocates assigning a body condition score to every animal said to be underweight and then repeat this after the animal has been fed to reach a so-called "ideal" weight. Merck then makes the extraordinary claim that if the animal's body condition increases with minimal or no medical intervention, this weight gain is "conclusive evidence of starvation."[7]

According to Merck, on a BCS scale of 1-9 (where 5 is said to be ideal) BCS 3 demonstrates a 10% loss of weight comprised entirely of body fat, whilst BCS 1 (described as "emaciated") is due to a minimum 20% weight loss comprised of ¾ fat and ¼ muscle. However, not only is this scientifically unsound, Merck's claimed source – Lusby, A.L. and C.A. Kirk's chapter on Obesity in Kirk's Current Veterinary Therapy XIV[8] – does not say this.

In fact, there is no scientific literature that states that an animal which is 20% below its so called "ideal" weight has lost weight or is, ipso facto, malnourished; nor does the literature equate a 20% weight loss to the severe functional muscle wastage generally associated with emaciation. Much depends on the original body composition of the animal, previous diet and rapidity of any weight loss, but studies suggest that 20% weight loss due to total food deprivation involves far from a total depletion of adipose tissue.[9]

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[7] As opposed to being caused by a disease process.

[8] Lusby, A.L. and C.A. Kirk. 2009. Obesity. In: Kirk's Current Veterinary Therapy XIV, Fourteenth edition, J.D. Bonagura and D.C. Twedt, eds. pp. 191–195. St. Louis: Saunders Elsevier."

[9] See Frommel D, Gautier M, Questiaux E, Schwarzenberg L. Voluntary total fasting:a challenge for the medical community. Lancet 1984;1:1451. Citing Cahill GF Jr. Starvation in man. Clin Endocrinol Metab. 1976;5:397-415.

Indeed, many BCS charts do not describe an animal in BCS 1 as being emaciated[10], or even having lost muscle. It is also far from clear what is actually meant by "emaciation" in the context of BCS charts; or how this emotive and ill-defined term came to be used as a descriptor in some BCS charts and not others.

Lusby & Kirk's BCS illustration (which combines dogs and cats in one chart – and relates to no other animal) merely suggests that there is an estimated 5% difference in body fat between each BCS score[11] and gives no basis for determining whether the cat or dog under examination has gained weight, lost weight, or remained stable. It also indicates, somewhat arbitrarily, that a cat or dog in ideal BCS 5 will have 20-24% body fat, while a cat or dog in BCS 1 is likely to have less than or equal to 5% body fat. Yet that is not the same as saying that an animal which is 20% under "ideal" weight is emaciated and/or suffering, nor that an animal has lost weight if it has a BCS of less than 5.

Lusby & Kirk's illustration varies significantly from the BCS charts issued by the European Pet Food Industry Federation ("FEDIAF"),[12] which are also based on the skewed Purina research. These suggest that a dog in "ideal" body condition will have 15-25% body fat[13] and a cat 20-30% body fat, further indicating that a dog with a BCS 1 is likely to have 4% body fat or less, and a cat in BCS 1 will have 10% or less body fat. This appears to be based on nothing more than an arbitrary presumption that there is a 5% difference in body fat between each BCS integer on the 9-point scale.[14] However, the FEDIAF chart additionally indicates that a cat or dog of BCS 1 (and described as being emaciated) is likely to be at least 40% below "ideal" body weight.

Other studies of dogs and cats have shown even greater variance in healthy/normal body fat content. A healthy adult Greyhound, for instance, is likely to have 7.2% body fat; whereas a healthy Siberian Husky may have 31% body fat.[15]

One US study of 133 neutered adult cats found that cats with an attributed "ideal" BCS had an average of 12% body fat, and suggested that anything above this figure was technically

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[10] See for example: Royal Canin BCS charts for cats and dogs which describe BCS 1-3 as too thin, BCS 4-5 as ideal, BCS 6-7 as overweight and BCS 8-9 as obese.; and red tractor scheme of dairy cattle (https://assurance.redtractor.org.uk/contentfiles/Farmers-5476.pdf?_=635912156462522175) which describes BCS 1 as poor, and BCS 5 as grossly fat, suggesting that BCS 2-3 is ideal.

[11] Other BCS studies have suggested a difference of up to 8.7% between each integer, but again these studies are based on animals in the mid to high range of BCS. See Mawby DI, Bartges JW, d'Avignon A, et al. Comparison of various methods for estimating body fat in dogs. JAAHA 2004; 40: 109-114.; Burkholder WJ. Use of body condition scores in clinical assessment of the provision of optimal nutrition. J Am Vet Med Assoc. 2000;217:650–3. It also seems likely that these increments only relate to increases in body fat from ideal, as opposed to decreases from ideal BCS.; (see also [12], [15] post).

[12] http://www.fediaf.org/component/attachments/attachments.html?task=download&id=48. See also footnote [6] ante.

[13] Although it seems Laflamme's research actually suggest that a dog in BCS 5 "ideal" will have body fat of 19%±8%. (cited in: Effect of breed on body composition and comparison between various methods to estimate body composition in dogs. (see [15] post). Whereas, Mawby DI, Bartges JW, d'Avignon A, et al. in Comparison of various methods for estimating body fat in dogs. JAAHA 2004; 40: 109-114., put BCS 5 at 11%±2% body fat in their study.

[14] But see footnote [11] ante. There appears to be no scientific literature that supports the proposition that a cat (or any other animal) with 10% body fat is emaciated. Studies show that an active fit male human can remain healthy at 4%-5% body fat see: Friedl KE, Moore RJ, Martinez-Lopez LE, Vogel JA, Askew EW, Marchitelli LJ, Hoyt RW, and Gordon CC. Lower limit of body fat in healthy active men. J Appl Physiol 77: 933–940, 1994.; Friedl KE, Moore RJ, Hoyt RW, Marchitelli LJ, Martinez-Lopez LE & Askew EW 2000. Endocrine markers of semistarvation in healthy lean men in a multistressor environment. Journal of Applied Physiology 88 1820–1830.

[15] Jeusette, I., et al. Effect of breed on body composition and comparison between various methods to estimate body composition in dogs. Res. Vet. Sci. (2009), doi:10.1016/j.rvsc.2009.07.009

obese.[16] However, it appears that even these figures can vary significantly at individual level within the same breed, with much being dependent on which BCS descriptors are being used as well as the experience and subjective bias of the evaluator.

Merck fails to accommodate the obvious possibility that an animal's weight may be stable and was never at an estimated "ideal" weight. Nor does she recognise that an individual animal's weight can vary greatly depending on genetics and level of physical activity. In relation to dogs, for example, so called "optimum weight" may vary as much as 40% between individuals of certain breeds.[17] It also seems that recommended dog breed weights are in need of systemic review,[18] and it is well established that current weight alone is not a good indicator of body composition;[19] nor can it provide a means of establishing weight loss[20] or rate of weight loss.

Merck's overly simplistic approach neglects such studies. With an apparent disregard for the need for expert reliability required in criminal prosecutions, she erroneously advises investigators that weight loss can be estimated by subtracting the weight of the animal on seizure from an estimated ideal weight for the species or breed. Alarmingly, Merck further suggests that it is preferable to <u>overestimate</u> weight loss, as an underestimation might, as she puts it, "compromise the criminal prosecution." Such improper suggestions not only represent a violation of the fundamental principles of scientific enquiry, but potentially amount to a brazen encouragement to "expert" witnesses to become parties to possible miscarriages of justice.

Equally worrying is Merck's suggestion that a study involving the total caloric restriction of obese dogs[21] provides a forensic basis for calculating how long it has taken for an animal, alleged to have been starved, to reach a specific BCS. Merck tells us that the study found that, on average, dogs lost 8% weight in the first week, 5% in the second week, and 3-4% per week thereafter over a total period of six weeks.

However, Merck fails to explain that rate of weight loss and the ratio of protein to fat utilisation differs significantly in obese and lean animals;[22] differs when there is total as

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[16] Anna K Shoveller, Joe DiGennaro, Cynthia Lanman, and Dawn Spangler (2014) Trained vs untrained evaluator assessment of body condition score as a predictor of percent body fat in adult cats. Journal of Feline Medicine and Surgery Vol 16, Issue 12, pp. 957 – 965.; see also Bellows J, Center S, Darlstotle L, et al. Aging in cats: Common physical and functional changes. J Feline Med Surg 2016;18:533–550.

[17] Burkholder W (1994) Body Composition of Dogs Determined by Carcass Composition Analysis, Deuterium Oxide Dilution,Subjective and Objective Morphometry, and Bioelectrical Impedance. PhD Thesis. Veterinary Medical Sciences,Virginia Polytechnic Institute and State University,Blacksburg.

[18] Smith, E.G. and Davies, K. et al (2018) Canine recommended breed weight ranges are not a good predictor of an ideal body condition score. J Anim Physiol Anim Nutr [102(4):1088-1090]

[19] Stanton CA, Hama DW, Johnson DE, Fettman MJ. Bioelectrical impedance and zoometry for body composition analysis in domestic cats. Am J Vet Res. 1992;53:251–7.

[20] Morgan DB, Hill GL, Burkinshaw L. The assessment of weight loss from a single measurement of body weight: the problems and limitations. AmJ Clin Nutr. 1980;33(10):2101-2105. Demonstrating that 25% of the patients in the study, with a stable weight, would have been wrongly diagnosed as having lost weight by using estimated weight guides.

[21] Merck's cited source is Anderson, G.L. and L.D. Lewis. 1980. Obesity. In: Current Veterinary Therapy VII, pp. 1034–1039. Philadelphia: W.B. Saunders Company. See also Allen, T.A. & Toll, P.W. (1995) Medical implications of fasting and starvation. In: Kirk's Current Veterinary Therapy XII: Small Animal Practice (ed. J.D. Bonagura). W.B. Saunders, Philadelphia, USA.

[22] Elia M. Effect of starvation and very low calorie diets on protein-energy interrelationships in lean and obese subjects. In: Scrimshaw N, Schurch B (eds). Protein-Energy Interactions. International Dietary Energy Consultancy Group, Proceedings of an IDECG workshop. Lausanne: Nestle Foundation, 1991, pp. 249–284.; see also: Cherel Y, Robin JP, Heitz A, Calgari C & Le Maho Y (1992) Relationships between lipid availability and protein utilization during prolonged fasting. Journal of Comparative Physiology162B, 305–313; De Bruijne JJ. Biochemical observations during total starvation in dogs. Int JObes. 1979;3:239–247. (In which obese dogs given only water for 3 weeks showed an average 18% loss of initial body weight, whereas non-obese dogs lost 24% body weight in the same time period).

opposed to partial food deprivation; and can differ between individual animals of the same breed. Merck also neglects to make it clear that this was merely a study of therapeutic fasting involving only 6 dogs, or that each dog's participation in the study stopped as soon as its individual goal weight was reached (24-42 days). Far from being a study of the cruel effects of starvation, the study concluded that fasting was a safe and possible useful means of tackling pet obesity in the clinical setting.

Merck's inappropriate use of this study has led vets, relying on her book in criminal prosecutions to arbitrarily pluck figures out of the air as to the length of time an animal has been "suffering" and/or "neglected" and, hence, the period of the defendant's alleged criminality. One vet, who regularly appears in RSPCA prosecutions, has used Merck's book to misinform the court that there is so little scientific research into animal starvation, experts are supposedly "slightly stuck" with this one experiment! In fact, there is a wealth of research into the effects of fasting, starvation, and food limitation in both animals and mankind going back more than a century.[23] But much of this learning is at a highly-specialised level, well beyond the knowledge, training and needs of the average clinical veterinary practitioner.

Merck's superficial approach neglects the fact that a thin animal (like a thin human) with low body fat may well be a fit, healthy animal. It has also led some prosecution vets to claim, solely on the amount of weight gained following seizure, that an animal was suffering from starvation when it was seized, even when they had not thought it was suffering at the initial examination.

Any fit, heathy animal will readily put on weight when it's exercise regime is reduced, and food energy intake increases; which is what happens in many RSPCA cases where seized animals are kennelled or stabled for much of the day. It is especially true of animals with so called "thrifty genes."[24] Yet weight gain, from a subjective low BCS, is frequently the only evidence adduced to support a claim that an otherwise bright and alert animal with normal vital signs has been "starved". Faced with such evidence, though, a high street solicitor will frequently advise their client that there is "no defence to the charges".

In one RSPCA prosecution, the owner of 2 lively giant cross-bred dogs, which had not reached maturity, was prosecuted for underfeeding her dogs solely on the basis that they had rapidly gained 20-25% body weight in the RSPCA's care. It was only when the defence inspected the ongoing boarding records, that it became apparent that both dogs had peaked in weight whilst still immature, and had therefore seemingly been overfed. In the 2 years that it took for the appeal against conviction to be heard, the by then mature dogs were about the same weight as, or less than, their peak weight.

A worrying feature of such cases, i.e. where immature large breed dogs are caused to gain weight too rapidly, is the increased risk of hip dysplasia or other developmental orthopaedic

[23] See for example Jackson CM, 1925. The Effects of Inanition and Malnutrition upon Growth and Structure. Philadelphia. P Blackiston's Son & Co.; Lusk, G., 1928. The Elements of the Science of Nutrition. W.B. Saunders Co., Philadelphia.; see also [69],[73] post.

[24] See for example Johnson P.J., et al. (2009) Medical Implications of Obesity in Horses—Lessons for Human Obesity. Journal of Diabetes Science and Technology; 3 (1) 163-174.; Dyson M.C., et al. (2006) Components of Metabolic Syndrome and Coronary Artery Disease in Female Ossabaw Swine Fed Excess Atherogenic Diet. Comparative Medicine; 56 (1) 35-45.

diseases.[25] These are serious conditions that could impact on the animal throughout its later life.

A lifetime study of 48 Labrador Retriever dogs,[26] half of which were fed a restricted diet, illustrates the implausibility of Merck's 20% below ideal weight definition of emaciation and suffering. The feed-restricted dogs proved to be longer lived with fewer osteoarthritic and other health problems than an "ideal" control group; notwithstanding their 25-30% lower body weight.

The study involved pairing the dogs by sex and weight within litters at 8 weeks old. One of each pair was randomly assigned to either a control-fed group or a dietary restricted group that received 25% less food. At 2 years of age the dietary restricted dogs weighed 53% - 95.9% of their pair-mate's weight. Despite this huge variability in body weight (demonstrating metabolic individuality) all the dogs were healthy.[27]

By 5 years of age the average body weight of the control group, which had been fed a diet calculated to maintain ideal body weight and prevent insidious obesity,[28] was 32.5kg compared with 22.5kg for the dietary restricted group.[29] To put these weights in context, the American Kennel Club's recommended breed weights for adult Labrador Retrievers are 29-36kg for males and 25-32kg for females.

From the ages of 6 to 12 years, all the dogs experienced significant increases in body fat. However, the dietary restricted dogs, who consistently weighed an average of 25% less than the control group, retained their accumulated lean body mass and bone mass for approximately 2 years longer; ultimately living an average of 1.8 years longer. [30]

As a result, the study recommended maintaining growing puppies and adult dogs at a slender body conformation to minimize development of osteoarthritis in aging.

Similar studies involving other animals, including humans, have also demonstrated significant health benefits of calorie restriction without malnutrition,[31] suggesting that a thin animal, requiring no medical intervention, may be far from suffering, even when initial weight loss has been significant .

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[25] Dammrich, K. 1991. Relationship between nutrition and bone growth in large and giant dogs. Journal of Nutrition 121:S114–S121. See also [26]-[30] post.

[26] Kealy RD; et al (2002) Effects of diet restriction on life span and age-related changes in dogs. J Am Vet Med Assoc Vol 220: 1315-1320.; Huck et al (2009) A Longitudinal Study of the Influence of Lifetime Food Restriction on Development of Osteoarthritis in the Canine Elbow. Veterinary Surgery 38:192–198

[27] Kealy RD; et al (1992) Effects of limited food consumption on the incidence of hip dysplasia in growing dogs. J Am Vet Med Assoc. 201(6):857-63;.

[28] Kealy RD; et al (2000) Evaluation of the effect of limited food consumption on radiographic evidence of osteoarthritis in dogs. J Am Vet Med Assoc. 217(11): 1678-80

[29] Kealy RD, et al. Five-year longitudinal study on limited food consumption and development of osteoarthritis in coxofemoral joints of dogs. J Am Vet Med Assoc ;210:222–225.;

[30] Dennis F. Lawler et al. (2008) Diet restriction and ageing in the dog: major observations over two decades. British Journal of Nutrition (2008), 99, 793–805.; Kealy RD; et al. (2002) Effects of diet restriction on life span and age-related changes in dogs. J Am Vet Med Assoc Vol 220: 1315-1320.

[31] See for example: Most, J., Tosti, V., Redman, L. M., & Fontana, L. (2017). Calorie restriction in humans: An update. Ageing Research Reviews, 39,36–45. https://doi.org/10.1016/j.arr.2016.08.005 .; Balasubramanian, P.; Howell, P.R.; Anderson, R.M. Aging and Caloric Restriction Research: A Biological Perspective with Translational Potential. EBioMedicine 2017, 21, 37–44.

In September 1991, 4 men and 4 women, all of whom were considered lean and healthy, were sealed into the "Biosphere 2" (a giant glass ecosystem research facility in the Arizona desert) for a period of two years. During this time they endured a 25%-30% calorie restricted, but nutrient dense, diet relative to the large amount of physical labour required to farm and process their own food.

In the first 6 months, as a result of crop problems, caloric intake averaged 1784 kcal/day (it had been calculated that they would require 2500Kcal/day). This led to significant weight losses in all 8 subjects ranging from 9-24%. Their weight remained stable at this reduced level when daily caloric intake increased to about 2000 kcal/day for the rest of their confinement. Notwithstanding the persistent calorie-restricted diet and the marked weight losses, all participants remained in excellent health and sustained a high level of physical and mental activity throughout the entire two years[32].

As with many animal studies, the participants also experienced lower cholesterol, lower blood pressure, lower basal metabolic rate, and lower blood glucose and insulin levels whilst at the same time increasing energy efficiency.

Animals have naturally evolved adaptive metabolic responses to cope with circadian, seasonal, and unpredictable food limitation[33]. The main response is to mobilise endogenous energy stores (body fat) and increase energy efficiency. The calorie-restricted Labradors, for instance, required 17% less energy than the control group to maintain each kg of lean tissue.[34] And ponies native to environments where winter forage is scarce, exhibit seasonally adaptive mechanisms to suppress metabolic rate, appetite and body mass/growth over the winter months[35].

What is less natural, for many animals, is the constant access to energy-dense foods associated with the industrialised Western World. A growing body of evidence suggests that the resulting chronically-fed state is fueling the obesity crisis in both humans and companion animals.[36] It is no coincidence that obesity is rarely found in the animal

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[32] Walford, R. L., Mock, D., Verdery, R. & MacCallum, T. Calorie restriction in Biosphere 2: alterations in physiologic, hematologic, hormonal, and biochemical parameters in humans restricted for a 2-year period. J. Gerontol. A Biol. Sci. Med. Sci. 57, B211–B224 (2002).; Weyer C, Walford RL, Harper IT, et al. Energy metabolism after 2 y of energy restriction: the Biosphere 2 experiment. Am J Clin Nutr 2000;71:946–53.

[33] See for example: McCue MD; et al (2017) Learning to starve: impacts of food limitation beyond the stress period. Journal of Experimental Biology 220: 4330-4338.; Comparative Physiology of Fasting, Starvation and Food Limitation (ed.M. D. McCue).; Weiss E.P. and Fontana L: Metabolic Consequences of Calorie Restriction. In Modern nutrition in health and disease 11th ed. / editors, A. Catharine Ross ... [et al.].; Hoffer L.J Metabolic Consequences of Starvation. In Modern nutrition in health and disease 11th ed. / editors, A. Catharine Ross ... [et al.]. Ng'oma E, Perinchery AM, King EG. 2017 How to get the most bang for your buck: the evolution and physiology of
nutrition-dependent resource allocation strategies. Proc. R. Soc. B 284: 20170445. http://dx.doi.org/10.1098/rspb.2017.0445

[34] Dennis F. Lawler et al. (2008) Diet restriction and ageing in the dog: major observations over two decades. British Journal of Nutrition (2008), 99, 793–805.; Kealy RD; et al. (2002) Effects of diet restriction on life span and age-related changes in dogs. J Am Vet Med Assoc Vol 220: 1315-1320.

[35] See Dugdale, A., Curtis, G., Cripps, P., Harris, P., & Argo, C. (2011). Effects of season and body condition on appetite, body mass and body composition in ad libitum fed pony mares. The Veterinary Journal, 190(3), 329-337.

[36] Neel JV. Diabetes mellitus: a "thrifty" genotype rendered detrimental by "progress"? Am J Hum Genet. 1962;14:353-362.; Kopelman PG (2000) Obesity as a medical problem. Nature 404, 635-643. German, A.J., 2006.; The growing problem of obesity in dogs and cats. Journal of Nutrition 136(Suppl.), 1940S–1946S.; Sillence, M., Noble, G., McGowan, C., 2006. Fast food and fat fillies: The ills of western civilisation. The Veterinary Journal 172, 396–397.; see also [37] post.

kingdom, other than in animals (e.g., pets) which have been overfed by man, or else when excess calories are unnaturally readily available.[37]

In *Medical Implications of Obesity in Horses—Lessons for Human Obesity*,[38] Johnson*, et al.* explain that the reasons for domesticated animals developing obesity are broadly similar to that in humans: in horses obesity is said to be due to contemporary husbandry practices and "attractive advertising" by the influential equine food industry which leads to the provision of energy-rich rations to physically inactive horses.

The problem is that horses and ponies evolved to survive on grass forage. Under natural circumstances (unlike many of today's equines who are often stabled for much of the day) they would cover great distances foraging, from 12 to 20 hours a day, to satisfy their nutritional requirements.

In readiness for winter, some horses and ponies have been found to increase secretions of important hormonal peptides[39] which drive storage of increased levels of body fat for use as energy over the winter months. Both increased insulin resistance and the development of a mild-to-moderate pro-inflammatory state accompany this increase in fat storage; but are resolved in parallel with the complete depletion of this additional fat before the arrival of the spring grass.

However, increased insulin resistance caused by excessive, chronic, and persistent adiposity (which does not deplete over the winter months) has been shown to have significant adverse effects on health; including increased risk of laminitis, colic and other diseases associated with Equine Metabolic Syndrome (EMS). Welsh Mountain ponies, and many (inactive) pleasure/leisure horse and pony breeds, are particularly at risk if fed rations that are too energy-dense, relative to the little exercise they perform.

Johnson, et al. point to the under-recognition of obesity in horses and ponies, by both veterinary clinicians and horse owners, as being a major problem in rising obesity levels. In a study of 319 pleasure riding horses in Scotland, only 50% of the owners of genuinely fat horses were found to have estimated their horse's BCS correctly.[40] The problem is that as fatness becomes "normalised", normal or lean animals may wrongly be assessed as being too thin.

Poor equine vet BCS assessment skills was also commented on by Dr. Sue Dyson FRCVS in her address on horse obesity at the World Horse Welfare Conference in 2015[41]. Dr Dyson, who is Head of Equine Clinical Orthopaedics at the Animal Health Trust, points out there is

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[37] Cronise RJ, Sinclair DA, Bremer AA. Oxidative priority, meal frequency, and the energy economy of food and activity: implications for longevity, obesity, and cardiometabolic disease. Metab Syndr Relat Disord 2017; 15: 6–17.

[38] Journal of Diabetes Science and Technology; 3 (1) 163-174.

[39] Pro-opiomelanocortin (POMC) peptides. See Medical Implications of Obesity in Horses—Lessons for Human Obesity (ibid).; Donaldson MT, McDonnell SM, Schanbacher BJ, Lamb SV, McFarlane D, Beech J. Variation in plasma adrenocorticotropic hormone concentration and dexamethasone suppression test results with season, age, and sex in healthy ponies and horses. J Vet Intern Med. 2005;19(2):217-22.

[40] Wyse CA, McNie KA, Tannahil VJ, Love S, Murray JK. 2008. Prevalence of obesity in riding horses in Scotland. Veterinary Record 162:590–591 DOI 10.1136/vr.162.18.590.

[41] The silent killer: is fat really a welfare problem? https://youtu.be/0HV2Af48Hi4?t=8445. See the audience Q&A with Sue Dyson's after her main address for comments of equine vets abilities in relation to BCS.

nothing wrong with being able to see the ribs on a fit lean horse. This is also reflected in the National Equine Welfare Protocol (2008):

> "It should be borne in mind that lean competition horses may have visible ribs and there are a number of veterinary conditions that can cause an animal to lose weight, so the visibility of the ribs does not necessarily imply neglect"[42]

The propensity to underestimate horse body condition concerned Dr. Don Henneke, Ph.D., who developed the original horse BCS system at Texas A & M University in the early 1980's[43].

In a 2012 press release[44] entitled *(Mis)use of the Body Condition Scoring System for Horses,*[45] Henneke criticised the tendency of "evaluators" for animal welfare charities and local authorities to exhibit personal biases that lowered their BCS estimate.

Henneke's press release came after the numbers of alleged horse neglect cases had skyrocketed across the United States. His concern was that Body Condition Scoring had become, in many if not most cases, the sole reason for alleging neglect or abuse; when in fact BCS was not designed to reflect the health or well-being of the horse:

> "The BCS provides an estimate of stored body fat, period. From a physiological standpoint, as long as a horse has any fat reserves and is receiving a diet that meets its daily maintenance requirements, that horse can be healthy."

Henneke' BCS system uses a 9-point scale (poor -to- extremely fat) to assess apparent adiposity and was adopted by The USA National Research Council[46] and a multitude of Equine Welfare Charities across the USA. However, publications such as *The Minimum Standards of Horse Care in the State of* California (2011) have arbitrarily insisted that any horse or pony with a BCS of less than 3 does not meet the "minimum standard".

But as Henneke points out:

> "By definition, a BCS 3 horse still has reserves of body fat. Once a horse gets below a BCS 3, then reserves are low. However, the health of the horse is only in jeopardy if it is breaking down non-fat tissue to provide for its basic energy needs. The BCS cannot measure this function."

[42] https://www.britishhorseracing.com/wp-content/uploads/2014/03/National_Equine_Welfare_Protocol-1.pdf
[43] Henneke, D.R., Potter, G.D., Kreider, J.L. and Yeates, B.F. (1983) Relationship between condition score, physical measurements and body fat percentage in mares
[44] The press release attributed to Henneke was published in March 2012, https://www.chronofhorse.com/forum/forum/discussion-forums/off-course/184730-dr-henneke-issues-a-new-statement, however Dr Henneke died of cancer 9 months later on 16th November 2012: https://thehorse.com/118672/henneke-developed-equine-body-condition-scoring-system-dies-at-60/ And unsurprisingly there are no communications to verify the contents of the press release. Although, as this paper seeks to demonstrate, the observation in the press release are scientifically sound.
[45] https://www.equinescience.org/BCS_Henneke.pdf
[46] Nutrient Requirement of Horses (1989) 5th Ed

Moreover, the BCS system was not even designed to be exact; and cannot be exact because of differences in breeds, size, age, and conformation between horses.[47] Nor can it differentiate individual variances in regional adiposity that may indicate an increased risk of disease in horses and ponies.[48]

As in the U.S, over the past decade hundreds, if not thousands, of horses in England and Wales have been seized on the basis of an allegedly low BCS. Although in the UK a 6-point scale (BCS 0-5) adopted by the National Equine Welfare Council (NEWC) and by DEFRA, in their respective equine welfare codes of practice, is generally used.

NEWC's guidelines[49] states that: a horse's body condition should ideally be maintained at BCS 3 (described as "good" on a scale of "very poor" to "very fat"), varying no more than half a point in either direction. According to NEWC, if BCS declines to 2 ("moderate") or below, action should be taken to correct this, including seeking veterinary advice as soon as possible if the horse's BCS falls below 2. As a result of these guidelines, many people in England and Wales have been prosecuted for causing suffering or neglect by failing to take action or obtain veterinary advice if their horse is subjectively adjudged to be at BCS 2 or below at the time of an RSPCA inspection.

Henneke's criticisms in relation to arbitrary minimum standards are equally applicable to NEWC's guidelines.

NEWC state that their BCS chart is based on the "Carroll and Huntingdon Method"- which used a BCS scale adapted from dairy cattle as part of a formulae to predict horse weight.[50] It is noteworthy that the study, which involved almost 400 horses with attributed BCS of 1-5, does not suggest that any of the horses in BCS 1 or 2 were suffering, neglected, emaciated, or in need of veterinary attention. As such, NEWC's insistence on year round maintenance of a minimum of BCS 2.5 appears both arbitrary and unscientific.

The fact that horses at BCS 2 or below on the 0-5 scale may be healthy, rather than suffering, should not surprise those with knowledge of endurance horse racing in the USA. A horse must be deemed fit by a vet before the race starts; and must pass further regular veterinary assessment at set points along the course.

One such race, the "Western States 100 Miles in One Day Trail Ride" (traditionally known as the Tevis Cup), covers an extremely challenging and rugged 160 km (100 mile) course over the Sierra Nevada mountain range. Participants must ascend a total of 6030m in elevation and descend 7657m over often extremely steep, narrow trails which include mud, sand,

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[47] [44] ante.

[48] Carter RA, Geor RJ, Burton Staniar W, et al. Apparent adiposity assessed by standardised scoring systems and morphmetric measurements in horses and ponies. Vet J 2009;179:204–210. See also Dugdale, A.H.A., Curtis, G.C., Harris, P.A., Argo, C. McG., 2011a. Assessment of body fat in the pony: I. Relationships between the anatomical definition of adipose tissue, body composition and body condition. Equine Veterinary Journal 43, 552–561.

[49] The Equine Industry Welfare Guidelines Compendium for Horses, Ponies and Donkeys

[50] Carroll, C.L., Huntingdon, P.J., 1988. Body condition scoring and weight estimation in horses. Equine Vet. J. 20 (1), 42–45. The study relied on Leighton-Hardman's description of Body Condition Scores which uses photographs of horses as examples of BCS 1-5, whilst relying on a drawing to demonstrate a horse in BCS 0, with a descriptor that a horse in BCS 0 "appears emaciated" rather than stating it is emaciated. See Leighton-Hardman, A.C. (1980) Equine Nutrition, Pelham Books, London.p 9-17.

volcanic rock outcrops and river crossings with ambient temperatures ranging between 5-50°C.

A study in August 1995 and July 1996 assessed the pre-race Body Condition Scores of 360 horse participants as being between 1.5-5.5 on Henneke's 9-point scale[51]. Whilst only two of the 35 horses assessed as BCS 3 or below completed the arduous course, they were all deemed fit to enter the competition; completing on average 43 miles (range 22-52 miles).

According to Henneke, clinical signs of genuine starvation (in addition to a low BCS) must be present before concluding that a horse is suffering from nutritional neglect, emphasising that an energy-deprived horse will be lethargic and will usually show signs of dehydration, concentrated urine and decreased fecal output. Blood analysis is essential.[52] And although, as with humans, no individual biomarker can confirm nutritional deprivation; it is suggested that an evaluation of matching trends of blood parameters will help confirm whether or not an animal is being neglected.

Controlled animal studies have been used to examine the various biochemical responses to starvation (e.g. stable isotope composition,[53] lipid profiles, respiratory quotient (RQ), respiratory exchange ratio (RER), and circulating metabolites), and whilst not conclusive, it is thought these might be useful for assessing an animal's nutritional status.[54]

However, in many animal welfare prosecutions such tests are never carried out. Most prosecution vets insist that subjective body condition scoring alone is sufficient to conclusively diagnose malnutrition, starvation and suffering. Worryingly, courts frequently accept such incautious assertions as the basis for convicting owners of animals that show no sign at all of any illness or disease.

The idea that a vet can simply lay hands on a bright and alert active animal, and pronounce that it has been starved or malnourished by its owner lacks, amongst other things, forensic credibility. At least biochemical testing and haematology provide objective measures for the courts to consider on the criminal burden and standard of proof; although caution must still be exercised when interpreting results, particularly as the animal's history is likely to be unknown. It is inexplicable that such tests are not carried out if there are genuine grounds for believing that an animal has been starved.

A brief study of the literature relating to the diagnosis of human malnutrition (which exceeds that which relates to animals) demonstrates the superficiality of BCS as a method of "diagnosing" starvation or undernutrition.

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[51] Garlinghouse SE, Burrill MJ. Relationship of body condition score to completion rate during 160 km endurance races. Equine Vet J Suppl. 1999;30:591–5.

[52] For indications of the necessary blood tests and their interpretation see: Muñoz A, Riber C, Trigo P, Castejón F. Hematology and clinical pathology data in chronically starved horse. J Equine Vet Sci 2010a;30: 581–9.

[53] For a useful summary of the studies into Stable Isotope Composition and an assessment of previous diet or starvation, see: McCue, M.D., Pollock, E.D., 2008. Stable isotopes may provide evidence for starvation in reptiles. Rapid Commun. Mass Spectrom. 22, 14–24.

[54] McCue, M. D. (2010). Starvation physiology: Reviewing the different strategies animals use to survive a common challenge. Comp. Biochem. Physiol. A Physiol. 156, 1-18. DOI: 10.1016/j.cbpa.2010.01.002

Diagnosis of undernutrition in humans is complex, one problem being the lack of global consensus over the definition and the objective assessment of malnutrition.[55]

For instance, it has been suggested[56] that malnutrition can be defined as having a body mass index (BMI) of below 18.5kg/m^2; however, whilst BMI has good correlation with % body fat at population level, it has very limited predictive value at individual level. As was demonstrated by the inappropriate classification of a 19-year-old Olympic gymnast as being at high risk of malnutrition based on a BMI of 17.7kg/m^2 when she was admitted to hospital with acute appendicitis.[57] Despite its frequent use as such, BMI has never been validated as being diagnostic of malnutrition in the individual.[58]

Other assessments of malnutrition consider the levels of unintended weight loss, fat free mass, and diminished function.[59]

The American Society for Parenteral and Enteral Nutrition ("ASPEN") recognises that no single parameter is definitive for adult malnutrition. And recommend at least 2 out of 6 characteristics should be present before a diagnosis of malnutrition can be considered.[60]

Those characteristics are: (1) Insufficient energy intake; (2)Weight loss; (3)Loss of muscle mass; (4) Loss of subcutaneous fat; (5) Localised or generalised fluid accumulation that may mask weight loss; and (6) Diminished functional status as measured by hand-grip strength.

In the absence of serious trauma or disease,[61] insufficient food intake of 50% or less of estimated energy needs for a period of at least 1 month is considered relevant for severe malnutrition, whilst an intake of less than 75% of estimated energy needs for 3 months or more is a risk factor for moderate malnutrition.

In order for unintended weight loss to be considered a risk factor for moderate malnutrition (in the absence of disease) the suggested markers are: 5% weight loss in a month; 7.5% loss in 3 months; 10% loss in 6 months; or 20% loss in a year, whilst severe malnutrition may be indicated where these same % weight losses are exceeded in each time frame.

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[55] Soeters P, Bozzetti F, Cynober L, Forbes A, Shenkin A, Sobotka L. Defining malnutrition: a plea to rethink. Clin Nutr 2016. http://dx.doi.org/10.1016/j.clnu.2016.09.032.;
Teigen L.M. et al., Diagnosing clinical malnutrition: Perspectives from the past and implications for the future. Clin Nutr August 2018. https://doi.org/10.1016/j.clnesp.2018.05.006

[56] Cederholm T, Bosaeus I, Barazzoni R, Bauer J, Van Gossum A,Klek S, et al. Diagnostic criteria for malnutrition—an ESPEN consensus statement. Clin Nutr 2015;34:335-340.

[57] Gonzalez MC, Correia M, Heymsfield SB. A requiem for BMI in the clinical setting. Curr Opin Clin Nutr Metab Care 2017;20:314–21.

[58] Action contre la Faim – France: Adult Malnutrition in Emergencies An Overview of Diagnosis and Treatment. Version 3 September 2006 https://www.accioncontraelhambre.org/sites/default/files/documents/adult-malnutrition-in-emergencies.pdf ; see also Piers LS, Soares MJ, Frandsen SL, O'Dea K (2000). Indirect estimates of body composition are useful for groups but unreliable in individuals. Int J Obes Relat Metab Disord, 24:1145-1152.

[59] See [55] –[57] ante.; [60] post. See also Becker PJ, Nieman Carney L, Corkins MR, Monczka J, Smith E, Smith SE, Spear BA, White JV. Consensus statement of the Academy of Nutrition and Dietetics/American Society for Parenteral and Enteral Nutrition: indicators recommended for the identification and documentation of pediatric malnutrition (undernutrition). Journal of the Academy of Nutrition and Dietetics. 2014; 114(12):1988–2000.

[60] White JV, Guenter P, Jensen G, et al. Consensus statement of the Academy of Nutrition and Dietetics/American Society for Parenteral and Enteral Nutrition: characteristics recommended for the identification and documentation of adult malnutrition (undernutrition). JPEN J Parenter Enteral Nutr. 2012;36:275-283. doi: 10.1177/0148607112440285.

[61] Serious wounds, burns, diseases and infection such as sepsis cause significant increases in metabolic rate and protein catabolism; and lead to much greater rapid weight loss.

Of course, both unintended weight loss of more than 10% within 6 months and an intake of less than 75% estimated energy needs were present in the Biosphere 2 experiment, without there being malnutrition. Which is why diminished function is an essential diagnostic marker for malnutrition.

Fundamentally, insufficient food intake can only be considered to be medically significant when it has led to functional disturbances, such as muscle weakness. This was recognised by the European Society of Clinical Nutrition and Metabolism ("ESPEN") when they first defined malnutrition as:

> "a subacute or chronic state of nutrition, in which undernutrition has led to a change in body composition and diminished function"[62].

Diminished function was quickly apparent in the participants of "The Minnesota Starvation Experiment" of 1944-1945.[63] The experiment was designed to study the effects of chronic severe calorie deficiency with the aim of determining how best to re-feed the starving masses in famine affected Central Europe after the war; and usefully demonstrates the effects of both starvation and rehabilitation on the body, and the means by which these can be objectively tested and recorded.

Following a 12-week control period, 34 lean healthy adult men (with a normal daily caloric intake averaging 3150 kcal) completed a 6-month, semi-starvation diet. The diet, chosen to reflect that of victims of famine in Europe, comprised primarily of: potatoes, cabbage, turnips and cereals. It was low in fat and contained very little animal protein. During this time, the men's individual caloric intake varied between 1550-1850 kcal p/day; about 50% of their normal daily requirement. This was adjusted depending on rate of weight loss, with the aim of inducing an overall 25% reduction in weight. Throughout the experiment the men were expected to perform their normal work and leisure activities, and walk a set route covering 22 miles a week.

The period of starvation was followed by 12 weeks of refeeding in which the men were split into 4 groups, each group differing in caloric intake by successive steps of 400 Kcal p/day. Twelve of the participants were thereafter studied for a further year whilst eating ad-lib.

Every possible aspect of their starvation and rehabilitation journey was monitored and measured including: anthropomorphic body measurements; blood parameters; metabolic rate and energy efficiency; muscle and fat mass; bone density; and faecal output and composition. Even their semen was analysed.

The men rapidly lost 15% of their body weight in the first 12 weeks of semi-starvation, after which their rate of weight loss slowed. Photographs of the men sunbathing in the fourth

[62] See [55] ante. All subsequent definitions by ESPEN have also incorporated diminished function as a key element of malnutrition.
[63] Kalm LM, Semba RD. (2005). They starved so that others be better fed: remembering Ancel Keys and the Minnesota experiment. J Nutr135: 1347–1352.; Keys A (1948) Caloric Undernutrition and Starvation, with notes on Protein Deficiency. JAMA 138(7):500–511. doi:10.1001/jama.1948.62900070006007.; University of Minnesota video: "The Minnesota Semistarvation Experiment" http://www.epi.umn.edu/cvdepi/video/the-minnesota-semistarvation-experiment/.; see also footnotes [64],[65] post.

month of the experiment show that the men's "developing emaciation is evident at a casual glance"[64].

They experienced extreme weakness, lethargy, unremitting hunger, depression, anaemia, an abnormally low heart rate, reduced body temperature, a constant feeling of coldness, and oedema in their faces upon rising which shifted to their lower extremities during the day. They lost all interest in sex, and their semen showed marked abnormalities. By the end of the 6 months, they had, on average, lost over 24% of their original body weight (32% when corrected for oedema)[65] and somewhere between 27.4%[66] and 41% of active tissue[67].

At the start of the rehabilitation period, the men continued to lose weight as excess body fluids were released. None of the men regained their original body weight until many months after the end of the starvation period. The group fed the most calories (3200 kcal rising to 4000 kcal p/day after 6 weeks) gained 56% of their former weight in 12 weeks, whilst the group fed the least calories (2000 kcal rising to 2800 kcal p/day after 6 weeks) gained only 17% body weight. However, much of the weight gained was comprised of body fat as opposed to replenishment of wasted muscle and, generally, it took well over a year before functional normality was restored.

It was also a long time before the unremitting feeling of hunger left the volunteers, with some men consuming 7,000-10,000kcal p/day as soon as they were allowed to eat as much as they wanted.

These remarkably high intakes of food are not well tolerated in normal subjects, who may develop nausea, vomiting, and short-term aversions to large quantities of food. However, in malnourished animals, such high intakes are thought to be caused by physiological feedback signals which greatly increase appetite and increase ad-lib food intake (hyperphagia) in line with the severity of nutritional depletion.[68] As such, it is important that detailed evidence of how and what a seized animal ate in the weeks and months following seizure is obtained. Yet frequently the RSPCA refuse to disclose boarding records post seizure, and such records are never kept if the owner has been persuaded to sign over the animals to the RSPCA.

It seems these very high intakes of energy are often necessary for weight recovery, whether the weight loss was caused by severe calorie restriction or prolonged total food deprivation.

In a 1910 experiment[69] involving fasting and refeeding, a small, non-obese fox terrier lost over 45% of her body weight during 15 days of total food deprivation, consuming only water. She passed no fecal matter until the 7th day, and then only very little. On the 13th day she was so weak she could hardly stand. By 4pm on the 15th day she could not stand, and it was feared she would not make it through the night. She was then fed a small

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[64] Keys, A.; Brozek, J.; Henschel, A.; Mickelsen, O.; Taylor, HL. (1945) Experimental Starvation in Man - A Report from the Laboratory of Physiological Hygiene. Minneapolis, MN: University of Minnesota Minneapolis, MN.
[65] Keys, A. (1946). Human starvation and its consequences. Journal. American Dietetic Association, 22, 582-587.
[66] Muller MJ, Enderle J, Pourhassan M, et al. Metabolic adaptation to caloric restriction and subsequent refeeding: the Minnesota Starvation Experiment revisited. Am J Clin Nutr 2015;102:807-819. Citing: Keys A. The Biology of Human Starvation. University of Minnesota Press: Minneapolis; 1950.
[67] [64] ante. Active "tissue" defined by Ancel Keys as representing everything except fat, bone, blood and interstitial fluid.
[68] Elia M. Hunger disease. Clin Nutrition 2000;19:379-86
[69] Howe, P. E. (1910). Nitrogen partition in repeated fasting. PhD thesis, University of Illinois.

amount of food, of which she took half. By the evening, after she has consumed the remaining food, she was much stronger and walked to the front of her cage wagging her tail “like a new dog”. Over the next 4 days she regained 21% of her body weight even though she was fed a much reduced diet. Over the next 15 days she received 100% of her original pre-fasting diet, however she gained only a further 7% body weight, with virtually nothing gained in the last 3 days. As such, her diet was further increased: first to 150% and then to 200% of the original pre-fast diet. In total, it took 47 days to regain her former body weight.

This study can be contrasted with a recent RSPCA case, where a bright and alert Jack Russel (which had been assessed as “emaciated” purely on a subjective BCS and its current weight, with no supporting photographic evidence) rapidly gained weight when it was fed 20% more than its daily energy requirement (DER) from the outset. It also calls into question whether any weight gain was simply due to the animal being overfed and under exercised, as opposed to recovery from a previously underfed state. This is especially since there was no evidence of loss of function, lethargy, hyperphagia or abnormal blood parameters.

Hyperphagia should not be confused with rapid feeding which may, for example, be an adaptation to scavenging during the early stages of domestication of the dog. Dogs that retain this tendency can rapidly become obese if allowed to feed ad libitum. Also several breeds of dog have a reputation for being able to consume large meals very rapidly, and it is possible that this is a legacy of competitive feeding in the wolf.[70] However, frequently the RSPCA suggest that if a dog eats its first meal following seizure rapidly this is strong evidence that the animal is being underfed by its owner.

Some animals have been shown to benefit from skip-a-day feeding. This relatively mild form of starvation is increasingly being used by agriculturists to manage the body condition and health of animals that have been artificially selected for rapid growth such as chicken and pigs. The benefits of skip-a-day feeding and more intensive starvation protocols have been found to include reduced mortality and developmental abnormalities, enhanced meat quality, and improved feed conversion[71]. Even for non-production animals, such as fox hounds, skip-a-day feeding is often employed to keep the animals lean and fit. In the wild, wolves live a feast or famine lifestyle, meaning that they may go several days without a meal and then gorge on over 20 pounds of meat when a kill is made.

Generally, the length of time an animal can tolerate fasting depends on its size and adiposity at the outset of the fast; but it also depends on individual hormone levels and metabolic rate. For instance, in one study 8 adult female beagles remained healthy throughout a 21-day water-only fast, during which they lost up to 30% of their body weight.[72] And in another early 19th Century repeated fasting experiment,[73] an adult Scotch collie dog, lost 63% of his body weight during 117 days of total food deprivation which resulted in diminished

[70] John W. S. Bradshaw. *The Evolutionary Basis for the Feeding Behavior of Domestic Dogs (Canis familiaris) and Cats (Felis catus)*. The Journal of Nutrition, Volume 136, Issue 7, 1 July 2006, 1927S–1931S, https://doi.org/10.1093/jn/136.7.1927S. Citing Coppinger R, Schneider R. *Evolution of working dogs*. In: Serpell J, editor. *The domestic dog: its evolution, behaviour and interactions with people*.Cambridge University Press; 1995. p. 21–47. And Mugford RA. *External influences on the feeding of carnivores*. In: Kare MR,Maller O, editors. *The chemical senses and nutrition.* New York: Academic Press;1977. p. 25–50

[71] McCue, see [54] ante

[72] Brady LJ , Armstrong MK , Muiruri KL , Romsos DR , Bergen WG , Leveille GA . (1977) Influence of prolonged fasting in the dog on glucose turnover and blood metabolites. J Nutr 107: 1053-1060, 1977

[73] Howe PE, et al; (1912) The Journal of Biological Chemistry Vol XI 103-127

muscular function; following which he was successfully refed. Whilst such experiments are plainly unethical by today's standards, the usefulness of the resulting data cannot be ignored.

Larger animals withstand longer periods of fasting than smaller animals because they lose significantly less % body mass. For example, fasting gray seal pups weighing 45kg will lose body mass at the rate of 8g per kg of body weight p/day, compared to a kestrels weighing 0.12 kg which will lose 55g per kg of body weight p/day.[74] As such, while it takes seals and penguins 70 or more days to lose 50% of their initial body mass, small migrating birds may undergo a 30% reduction in body mass in a matter of hours.[75]

The responses to absolute food deprivation in birds and mammals also differs from that during calorie restriction. The initial period involves fasting, and the later stages starvation. After a short period of adaptation (phase I), a steady state of homeostasis is reached (phase II) during which the animal does not exhibit the levels of hunger, if at all, associated with severe calorie restriction.[76] In this stage, body fat is mobilized to provide 80–95% of the energy expended and proteins are greatly spared in order to maintain tissue structure and muscle function. As such, these animals do not 'starve' as the biochemical implications of starving differ greatly from those of successful fasting.

However, once 80–90% of fat reserves have been used, muscle protein catabolism increases dramatically (phase III); and it is generally considered that the transition from fasting to starvation occurs toward the end of phase II and beginning of phase III[77]. By this stage, voluntary intake of water will have significantly decreased, and sensations of hunger (which from human studies appear to be largely absent during much of phase II) are triggered, leading to increased activity in search of food.[78] As with spontaneously fasting birds, experiments in rats show that this increased locomotive activity is an important physiological adaption to long-term food deprivation.[79] However, if starvation continues, the rapid loss of muscle (which cannot be sustained for long) inevitably results in death from loss of heart, liver, or kidney function.

A major difference between recovery from weight loss brought about by severe calorie restriction, as opposed to that brought about by prolonged total food deprivation, is the order in which lean tissue and body fat is replenished. In severely calorie-restricted humans and animals, as in the Minnesota experiment, body fat is replenished much earlier than either

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[74] Secor, S.M., and Carey, H.V. (2016). Integrative physiology of fasting. Compr.Physiol. 6, 773–825. See also [21] ante.
[75] McCue, see [54] ante.
[76] For example see Anderson, G.L. and L.D. Lewis. 1980. Obesity. In: Current Veterinary Therapy VII, pp. 1034–1039. Philadelphia: W.B. Saunders Company. The loss of hunger sensation appears to be due to reduced levels the gastrointestinal peptide ghrelin induced by fasting. See for example Espelund, U., Hansen, T.K., Hojlund, K., Beck-Nielsen, H., Clausen, J.T., Hansen, B.S., et al., 2005. Fasting unmasks a strong inverse association between ghrelin and cortisol in serum: studies in obese and normal-weight subjects. The Journal of Clinical Endocrinology and Metabolism 90:741e746.
[77] Wang T, Hung CCY, Randall DJ. The comparative physiology of food deprivation: from feast to famine. Annu Rev Physiol. 2006;68: 223–51. Although see also [54]ante.
[78] Robin JP, Decrock F, Herzberg G, Mioskowski E, Le Maho Y, Bach A, Groscolas R (2008) Restoration of body energy reserves during refeeding in rats is dependent on both the intensity of energy restriction and the metabolic status at the onset of refeeding. J Nutr 138(5):861–866.
[79] Cherel Y, Le Maho Y (1991) Refeeding after the late increase in nitrogen excretion during prolonged fasting in the rat. Physiol Behav 50:345-349

body protein or weight. [80] Generally, it seems that subjects exhibit immediate hyperphagia upon refeeding. Although the extent of excessive food intake diminishes as weight is regained, it seems it is likely to persist until most, if not all, lean tissue is recovered, ultimately causing body fat to exceed pre-calorie restricted levels[81].

In contrast, animals recovering from prolonged total food deprivation restore full lean tissue earlier than body fat.[82] Upon refeeding, the animal's initial priority is to rehydrate; with feed intake increasing in parallel with water intake. As such, maximal hyperphagia (which in refed starved rats reaches the same levels as in refed calorie restricted rats) is delayed by several days. When David Blaine commenced refeeding following his much vaunted 44-day fast in a Perspex box suspended in the river Thames, according to his diary on day 5 of refeeding "my hunger grew out of proportion and I was eating almost a double portion of all meals."[83] Studies also suggest refed-starved animals require less food, in total, than calorie restricted animals in order to return to their former body weight.[84]

Although there can be significant variability between individual animals within the same breed and species, the level of depletion in body fat, intensity of the energy restriction (i.e. partial or total), and the metabolic status of the animal at the onset of refeeding are the most important predictors of how lean and fat tissue will be restored.[85]

These pronounced biochemical and physiological responses to both starvation and refeeding are both measurable and recordable; suggesting that if an animal is truly suffering from malnourishment (or as a result of prolonged total food deprivation) there will be visual and physical signs on initial examination in terms of emaciation, lethargy, dehydration, abnormal or absent fecal excretion; together with biochemical markers in blood, fecal and urine samples. Upon refeeding, there is likely to be significant hyperphagia, and other physiological and biochemical changes. It is also seems unlikely that the animal will experience the rapid and easy weight gain suggested by Merck, and often encountered in RSPCA cases; or that any "emaciation" will not be obvious from photographs as was so clearly demonstrated in the Minnesota experiment and the many photographs of skeletal animals released to the press in genuine cases of food deprivation.

However, in many prosecutions involving bright and alert animals, the only evidence of underfeeding is: (1) the vet's Body Condition Score; (2) the difference between seizure weight and increased weight in RSPCA care; and (3) the vet's unshakeable (and unscientific) opinion that, because no evidence of disease or illness could be found, the animal's current weight and BCS can only be explained by insufficient food provision, which in turn has

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[80] Harris RB, Kasser TR, Martin RJ (1986) Dynamics of recovery of body composition after overfeeding, food restriction or starvation of mature female rats. The Journal of nutrition 116:2536-2546.

[81] Ibid.; Dulloo AG (1997) Human pattern of food intake and fuel-partitioning during weight recovery after starvation: a theory of autoregulation of body composition. Proceedings of the Nutrition Society 56, 25–40.; Dulloo AG, Jacquet J, Girardier L. Post starvation hyperphagia and body fat overshooting in humans: a role for feedback signals from lean and fat tissues. Am J Clin Nutr 1997;65:717–23.; Dulloo, A. G. & Girardier, L. (1990). Adaptive changes in energy expenditure during refeeding following low calorie intake: evidence for a specific metabolic component favouring fat storage. American Journal of Clinical Nutrition 52, 415-420.

[82] [77], [79] ante.

[83] Korbonits, M., Blaine, D., Elia, M., Powell-Tuck, J., 2007. Metabolic and hormonal changes during the refeeding period of prolonged fasting. European Journal of Endocrinology/European Federation of Endocrine Societies 157: 157e166.

[84] [79] ante

[85] Robin JP, Decrock F, Herzberg G, Mioskowski E, Le Maho Y, Bach A, Groscolas R (2008)Restoration of body energy reserves during refeeding in rats is dependent on both the intensity of energy restriction and the metabolic status at the onset of refeeding. J Nutr 138(5):861–866.; Dulloo AG, Jacquet J, and Girardier L. Autoregulation of body composition during weight recovery in human: the Minnesota Experiment revisited. Int J Obes 20: 393–405, 1996.

caused the animal to suffer. Such vets frequently give evidence that the BCS they have assigned ought to have been obvious to the owner, and that a reasonably humane owner would have known the animal was suffering and therefore taken action. Again, such statements are unscientific, arbitrary, and outside the expertise of a clinical veterinary practitioner.

When photographs taken of the animals appear to contradict assertions that the animal was emaciated, the stock response from both RSPCA vets and prosecutors is that it is not possible to accurately body condition score an animal from a photograph, and as such the evidence of the prosecution vet (being the only vet to handle the animal) ought to be preferred. Surprisingly, this explanation is often accepted by courts as a basis for rejecting evidence that challenges the validity of the assigned low BCS and the allegation of suffering. However, as a basic principle of criminal law the benefit of any doubt created by photographic evidence ought be given to the defence. In any event, photographic images of sufficient quality have been shown to allow a reasonable assessment of BCS.[86]

Courts have also been persuaded to reject evidence which challenges prosecution assertions that an animal which is 20% below ideal body weight is emaciated; with at least one defence vet receiving judicial criticism for relying on a well-respected veterinary dictionary which states that emaciation is generally taken to mean that *"body weight is less than 50% of the normal expected for a comparable normal animal."*[87] The court instead accepted the prosecution vet's erroneous evidence that, if a cat was 15-20% below average weight, it would be described as being emaciated; and that the "Australian veterinary dictionary" referred to by the defence vet was rarely used in the UK, and wasn't to be found in the RCVS library.[88] The defendant in that case was convicted due to this cavalier evidence, and was ordered to pay costs in excess of £100,000.

Unfortunately, such a cavalier approach to evidence by vets is not unique. And due to insufficient scrutiny of the scientific pedigree of such veterinary testimony, defendants regularly face allegations of underfeeding their animals on the unverifiable say-so of prosecution vets acting beyond their expertise. Diagnosis of malnutrition and fuel-partitioning (the way the body utilises and allocates resources) is barely taught at undergraduate/clinical practice level, and appears to be poorly understood by those vets relying on Melinda Merck's book as the basis for concluding that an animal has been starved.

Prosecution vets rarely explain the limitations of using BCS to the court, with some seeing nothing wrong with arbitrarily adapting their own scoring system from several different sources or from those devised for different species. For example: a vet who had never previously body condition scored goats, was found to have adapted a BCS method used for

[86] Gant et al. (2016) Can you estimate body composition in dogs from photographs? BMC Veterinary Research (2016) 12:18 DOI 10.1186/s12917-016-0642-7.; Vieira A, et Al. (2015) Development and validation of a visual body condition scoring system for dairy goats with picture-based training. Journal of Dairy Science Vol. 98 No. 9.; Hansen MF, et al., (Automated monitoring of dairy cow body condition, mobility and weight using a single 3D video capture device. Comput Ind. 2018 Jun; 98: 14–22.

[87] Saunders Comprehensive Veterinary Dictionary; by Douglas C. Blood OBE BVSc MVSc Hon LLD Hon DVSc HonAssocRCVS FACVSc and Virginia P. Studdert BSc DVM Hon DVSc.; see also https://www.vin.com/news/VINNews.aspx?articleId=27585

[88] The RCVS library's catalogue in fact shows the dictionary is in their library: https://knowledge.rcvs.org.uk/library-and-information-services/our-resources/

horses; another vet recently admitted to scoring snakes and lizards using cat and dog BCS charts; and other vets have assigned Body Condition Scores to cats, dogs and birds on a 0-5 scale, despite there being no such scale for these species.

Such vets, who express unwavering confidence in the correctness of their BCS, seem unaware that BCS repeatability and reproducibility are reduced if the defined criteria for each score is not provided at the time the assessment takes place,[89] or that using morphometric measurements as an indicator of nutritional status is inherently susceptible to error, inaccuracy and bias.[90]

Research in the swine industry has found that, irrespective of experience, evaluators tended to assign BCS on their own scale and have individual specific biases toward over- or underestimating BCS. As a result, scorers are advised to be cognisant of their average bias.[91] BCS has also been found to provide a relatively poor basis for determining feed requirements for breeding stock; and that ultrasonic measurements are much more precise.[92]

In horses, research which tested the accuracy of BCS in comparison with ultrasonic measurements of subcutaneous fat, found only a 47% correlation between the scores of the most experienced BCS evaluator participating in the study and the more objective results of an ultrasound scan. The research also found that the evaluator's ability to detect changes in body fat over time was significantly poorer,[93] and indicated that there was likely to be even greater variability of BCS among non-professionals. This conclusion is supported by other research which found that pet owners have a poor ability to "correctly" BCS their pets, notwithstanding being provided with BCS charts[94].

Furthermore, despite BCS not being a measure of muscle loss,[95] and Muscle Condition Scoring (MCS)[96] remaining unvalidated as a tool in clinical practice due to poor reproducibility between practitioners,[97] prosecution vets have managed to persuade courts that they were able to determine that an animal had lost muscle mass by palpating the animal on a single occasion. Not only is such evidence unverifiable and forensically unsound, it cannot be recorded in a way that enables a defence expert to evaluate it. As

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[89] Burkholder W (1994) Body Composition of Dogs Determined by Carcass Composition Analysis, Deuterium Oxide Dilution, Subjective and Objective Morphometry, and Bioelectrical Impedance. PhD Thesis. Veterinary Medical Sciences,Virginia Polytechnic Institute and State University,Blacksburg

[90] Ulijaszek SJ & Kerr DA (1999): Anthropometric error and the assessment of nutritional status. Br. J. Nutr. 82, 165–177.; A. Scafoglieri, J.P. Clarys, E. Cattrysse, I. Bautmans, Use of anthropometry for the prediction of regional body tissue distribution in adults: benefits and limitations in clinical practice, Aging Dis. 5 (6) (2014) 373–393.

[91] Fitzgerald, R. F., Stalder, K. J., Dixon, P. M., Johnson, A. K., Karriker, L. A., Jones, G. F., 2009. The accuracy and repeatability of sow body condition scoring. The Professional Animal Scientist 25, 415–425

[92] Young MG, Tokach MD, Aherne FX, Main RG, Dritz SS, Goodband RD, Nelssen JL. Comparison of three methods of feeding sows in gestation and the subsequent effects on lactation performance. J Anim Sci 2004;82:3058-3070.

[93] Mottet, R., Onan, G., Hiney, K., 2009. Revisiting the Henneke body condition scoring system: 25 years later. Journal of Equine Veterinary Science 29, 417–418

[94] Eastland-Jones R, German AJ, Holden SL, et al. (2014) Owner misperception of canine body condition persists despite use of BCS chart. J Nutr Sci (In the Press).; see also [40] ante.

[95] See [4] ante.

[96] Michel KE, Anderson W, Cupp C, Laflamme D. Validation of a subjective muscle mass scoring system for cats. J Anim Physiol Anim Nutr 2009; 93: 806 (abstract).;

[97] Michel KE, Anderson W, Cupp C, et al. Correlation of a feline muscle mass score with body composition determined by dual-energy x-ray absorptiometry. Br J Nutr 2011;106:S57–S59.; WSAVA Global Veterinary Development Nutritional Assessment Guidelines (2011) https://www.wsava.org/WSAVA/media/Documents/Guidelines/WSAVA-Global-Nutritional-Assessment-Guidelines-2011-final.pdf

such, both the integrity and fairness of the trial process is undermined if (as is frequently the case) such evidence is allowed to go before the court.

The Law Commission Report on Expert Evidence in Criminal Proceedings[98] raised concerns about the number of cases where expert opinion evidence of doubtful reliability is allowed to go before the trial court; finding that this is due to a laissez-faire approach to admissibility. And even though the essence of the report's recommendations have been introduced through Criminal Practice Directions,[99] there remains a systemic lack of scrutiny of the underlying basis of expert opinion evidence in Animal Welfare cases. Instead there appears to be an unwarranted assumption that all vets are experts in all things to do with animals, and can therefore proffer opinion on (1) highly complex physiological and biochemical matters; (2) the knowledge and beliefs of the ordinary pet owner; and (3) what animal welfare offences have been committed.

However, expert evidence ought only be admitted if: (1) the opinion is soundly based; (2) the strength of the opinion is warranted having regard to the grounds upon which it is based; and (3) it is of a nature that assists the court upon matters it would otherwise be unable to form sound judgment. As such, the question of what an ordinary pet owner knows, or would do in the alleged circumstances is not something about which a vet should ordinarily give evidence. Likewise, vets should not be giving evidence on what offences they believe have been committed. Yet frequently, prosecution "expert" veterinary reports and oral evidence are littered with such opinion.

Any vet instructed by a prosecuting agency (such as the RSPCA) to investigate and gather evidence of suffering or neglect, is bound by the *Codes of Practice and Conduct for Forensic Science Providers and Practitioners in the Criminal Justice System*. Paragraph 2.1.3 places a duty on the instructing agency to ensure that the expert abides by the Codes. The Codes, in essence, require that the expert is aware of the duty to retain, record and reveal evidence in a manner that will allow a defence expert to evaluate the examination of the animal and any conclusions drawn.[100] Additionally, the codes require that those providing forensic science services are aware of the need to: (1) use validated methods or procedures based on sound scientific principles and methodology; (2) demonstrate competence in using these methods or procedures, and evaluating the results obtained objectively and impartially, and according to established scientific and statistical methodology; and (3) consider the impact that confirmation/cognitive bias can have at different stages and use of avoidance strategies.

However, in RSPCA prosecutions, those instructed to provide veterinary opinion are often unaware of, and fail to meet, these criteria.

[98] Law Commission, Expert Evidence in Criminal Proceedings, Law Com. No.325, HC 829, available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/229043/0829.pdf

[99]See CPD 19. Criminal Practice Directions 2015 [2015] EWCA Crim 1567 Consolidated with Amendment No. 2 [2016] EWCA Crim 1714. https://www.judiciary.uk/wp-content/uploads/2016/11/cpd-2015-consolidated-with-amendment-no2-nov2016.pdf

[100] See the Codes of Practice generally; see also paragraph 5.1 of the 1997 Code of Practice under Part II of the Criminal Investigation and Procedure Act 1996 which imposes a duty on investigators (and those instructed by them) to retain material obtained in a criminal investigation which may be relevant to the investigation. This includes not only material coming into the possession of the investigator but also material generated by him material may be photographed, or retained in the form of a copy, rather than the original if the original is perishable.

As animals are living evidence, their current condition is "perishable." Therefore, in order for evidence to be retained, the examination of the animal needs to be recorded in a manner sufficient to fairly capture all relevant evidence. As such, video recording of the entire examination of the animal, together with side, top, front and rear angle photographs of the animals in line with BCS chart illustrations, ought to be a minimum standard if there is to be a fair trial.

Furthermore, objective, verifiable and recordable methods of determining body composition need to be used rather than unscientific BCS. Such methods include ultrasound, dual-energy X-ray absorptiometry (DEXA), deuterium oxide (D_2O) dilution, bioelectrical impedance analysis (BIA), and quantitative magnetic resonance (QMR). With QMR seeming to provide a non-invasive, precise, accurate, fast, and easy-to-use method for determining fat and lean mass without having to anesthetise the animal[101].

It is also basic in most criminal investigations, that blood and other samples should retained and stored in a manner that prevents contamination, avoids degradation, and ensures the chain of custody. Such processes should be sufficient to permit another competent expert to carry out their own evaluation of the evidence. However, in Animal Welfare cases, continuity of samples is generally poor, and many courts appear slow to recognise the unfairness this may cause the defence. If samples do exist, they are frequently omitted from disclosure schedules.

For instance, during one appeal against conviction, a veterinary pathologist (who was neither a forensic expert nor an expert in equines) produced unlabeled photographs of what was said to be histological samples taken from an alleged starved horse, stating that they unequivocally showed cell structure inconsistent with the defence case. Notwithstanding that neither the photographs nor the samples had appeared on a disclosure schedule, and that all previous indications had been that the organ concerned had been too heavily autolysed (i.e. the cells had broken down following death) for histological interpretation, the defence were given no real opportunity to evaluate the veracity of this ambush evidence.

Cases where the defence have been able to examine original exhibits, have sometimes revealed gross negligence, or worse, on the part of the prosecution and their experts. In one case, an owner was convicted of starving his dog to the point of emaciation based on the prosecution vet's evidence that the dog weighed only 19kg instead of its previously healthy 30kg (as seen from the dog's own vet records). However, when the defendant appealed his conviction, a postmortem by his own expert revealed that the carcass of the dog in fact weighed 29.6kg.[102]

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[101] Tinsley FC, Taicher GZ, Heiman ML (2004) Evaluation of a quantitative magnetic resonance method for mouse whole body composition analysis. Obes Res 12:150–160. https://doi.org/10.1038/ oby.2004.20.; B.M.Zanghi,C.J.Cupp,Y.Panetal., Noninvasive measurements of body composition and body water via quantitative magnetic resonance, deuterium water, and dual-energy x-ray absorptiometry in awake and sedated dogs. American journal of Veterinary Research,vol.74,no.5,pp.733–743,2013.; Warner DA, Johnson MS, Nagy TR. 2016. Validation of body condition indices and quantitative magnetic resonance in estimating body composition in a small lizard. J. Exp. Zool. 325A:588–597.; Riley JL, Baxter-Gilbert JH, Guglielmo CG, Litzgus JD. Scanning snakes to measure condition: a validation of quantitative magnetic resonance. J Herpetol. 2016; doi: 10.1670/15-113.

[102] See interview with barrister Joe Rich which also set out the difficulties encountered in obtaining blood samples from the Prosecution: https://www.ourdogs.co.uk/News/2009/July2009/News310709/rspca.htm

In many prosecutions, animals are not fully examined by the RSPCA-instructed vet until after they have been removed from the owners premises, and owners are rarely allowed to call their own vet to see the animals prior to removal. As such, owners are usually unaware of any specific allegation of underfeeding until many months, and potentially years,[103] after the animal has been seized. Which means that when the matter does come to trial, in the absence of adequately retained and recorded contemporaneous evidence, an owner has little more than their own word that the animal was properly fed and healthy during the charge period. Unfortunately, in practice, the courts appear to be slow to accept an owner's word in the face of the evidence of the prosecution vet.

Contrary to RSPCA claims, any unfairness this causes cannot be cured by offering an owner the opportunity to have a vet of their choice examine the animal in the days or weeks following seizure. This is because behavioral, physiological and biochemical changes can rapidly occur during transportation,[104] after an animal is removed from its normal environment, or when it's diet is changed. The animal may also have been treated and become subject of a different care regime. As such the evidence of how the animal presented at the time of seizure may no longer exist.

The effects of such changes is recognised in the various DEFRA codes of practice for cats, dogs and horses. In relation to cats, the codes advise caution before removing a cat to unfamiliar environments due to the stress this causes, and that any changes in diet should be made gradually. In dogs the codes advise that a sudden change in diet can cause a dog to suffer from digestive problems. And in relation to horses, DEFRA advises: "*Any diet changes (increase in volume, change in feed or hay etc.) should be made gradually. Sudden changes can lead to gastrointestinal upsets including colic and diarrhoea and should be avoided*".

Furthermore, transportation can affect the animal's weight, hydration levels and the reliability of blood markers as indicators of the condition an animal was in pre-seizure. A horse, for instance, can lose 5% of its body weight (about 0.5% per hour) during transportation. The horse will also show increased stress levels as measured by cortisol hormones in the blood; and increased levels of the enzymes (CK and AST) involved in the skeletal muscle activity necessary to maintain the horse's balance during transportation (a bit like the skeletal muscle used in vibration technology used in gyms and for astronauts).

Yet despite these changes, the weight of the animal, blood and fecal samples are usually only obtained after removal, and then often only once. As such, there is rarely an opportunity to observe the changes in biomarkers caused by seizure, or see if there are changes - for better or worse - over time.

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[103] Currently section of the 31 Animal Welfare Act 2006 is being interpreted so as to allow prosecutors, to lay an information within 6 months of when they have accumulated and considered all the evidence in the case and made a decision that it is in the public interest to bring a prosecution on the particular charges. However, there are considerable grounds to doubt that the law is being interpreted correctly in relation to time limits. See: Howe, SL. (2017) Prosecution Time Limits – is the Animal Welfare Act a ticking bomb? Part 1 CL&JW vol 181, 178-180; Howe, SL. (2017) Prosecution Time Limits – is the Animal Welfare Act a ticking bomb? Part 2 CL&JW vol 181, 196-199. Insufficient retention of evidence, and records thereof, increasingly diminish the prospects of a fair trial in parallel with the length of time it takes for any specific charge to be laid.

[104] EFSA Panel on Animal Health and Welfare (AHAW), 2011. Scientific opinion concerning the welfare of animals during transport. EFSA J. 20119:1966125.

When CK and AST levels have been raised, vets acting for the RSPCA have been known to categorically refute the possibility that this could be due to transportation; with one equine clinician going as far as to state that a healthy pony which had been assessed as BCS 4 (fat on a 0-5 scale) had been underfed - solely on the basis of such raised enzymes. As is frequently the case, the court preferred the flawed "certainty" of the prosecution vet's evidence over the differential assessment of the defence forensic veterinary expert.

This uneven manner in which many courts deal with prosecution veterinary evidence, as compared with that of the defence, suggests a systemic lack of understanding of the nature and requirements of forensic opinion evidence in these types of cases. With defence vet reticence often being criticised as being evasive, biased, or as an indication of an insufficient skill set to enable them to be as "certain" as the prosecution vet. However, as this paper has sought to expose, such certainty is often based on flawed assumptions on matters outside the expertise of the clinical vet.

It has been recognised by courts in other fields of criminal law that the effects of such flawed testimony can lead to serious miscarriages of justice. Most notably in the United Kingdom, when in 1999 Professor Sir Roy Meadow, an experienced paediatrician, provided statistically inaccurate testimony in the trial of Sally Clark for the murder of her two young sons. And similarly, in Canada, where the flawed testimony of Dr Charles Smith led to the wrongful convictions of parents said to have murdered their children in so called "shaken baby syndrome" cases.

Although animal welfare cases do not carry the same long custodial sentences imposed in murder cases, convictions for animal cruelty frequently incur life-time disqualifications from owning and dealing with animals; costs that can run in hundreds of thousands of pounds; and life-changing public condemnation. There is no reason for lower standards being applied to those giving expert evidence in Animal Welfare cases.

The findings of the Goudge Inquiry (2008), held in relation to the miscarriages of justice caused by Dr. Charles Smith, are a useful reminder of how easily injustices occur when a clinical expert witness either strays outside the area of their expertise and/or is unaware of, or unwilling to admit to, the limitations of their knowledge. Dr. Smith, who was a paediatric pathologist, not a forensic pathologist, told the inquiry that he did not regard forensic pathology as a separate discipline, though he had lectured and acquired an increasing reputation within that field. However, the Inquiry concluded that not only did Dr. Smith not have a basic understanding of forensic pathology but that he was unaware of the damaging impact that could have on the validity of his expert testimony, stating that:

> "The expert must be aware of the limits of his or her expertise, stay within them, and not exaggerate them to the court. Dr Smith did not observe this fundamental rule."[105]

[105] https://www.attorneygeneral.jus.gov.on.ca/inquiries/goudge/report/v1_en_pdf/Vol_1_Eng.pdf See exec summary p. 14;

As this paper has sought to demonstrate, the same criticisms can be made of a significant amount of the "expert" veterinary evidence in Animal Welfare cases in England and Wales. In part, the failings are due to the courts misplaced presumption, which some prosecutors encourage, that if a vet certifies an animal as suffering, the court "can't go behind that certification". However, as Stephen Wooler CB points out in his "*Independent Review of the prosecution activity of the Royal Society for the prevention of cruelty to animals"* ("the Wooler Report"), there is no commonly-recognised professional standard or approach to suffering within the veterinary profession because suffering is not a term that is used in routine clinical work. This means, as Wooler says, "expert" veterinary evidence relating to suffering may be no more than a personal, and therefore subjective, view.

If courts fail to adequately assess whether veterinary opinion is forensically sound, defendants will continue to be tried and convicted on the unscientific say-so of the prosecution vet.

Criminal law needs certainty, and convictions require a very high standard of proof. As Body Condition Scoring provides only an approximation of body composition, and gives no information on nutritional status, there are real grounds for concern that significant numbers of animal owners have been wrongly convicted on flawed, subjective and unverifiable evidence. BCS seems to be a tool of first (and only) resort for some prosecutors and their expert witnesses, when it is plain that this evidence should really have no role at all in the process.

There is, therefore, a pressing need for a fundamental re-examination of the way BCS evidence is used in animal cruelty prosecutions and assessed by the courts. BCS might be a useful tool to monitor obese animals in the clinical setting, or to assess feeding programmes over time in the livestock setting; however, Body Condition Scoring's very significant limitations in a forensic setting need to be acknowledged before more injustices occur. In particular, courts need to be aware that Body Condition Scoring lacks scientific validation as a diagnostic tool of suffering. Lawyers, judges and magistrates courts must also ensure that they are given the proper tools to scrutinize the assertions of apparently credible prosecution vets that a particular animal is suffering as a result of its body composition. Otherwise, these grave miscarriages of justice will continue to occur.

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