MEANDERING THROUGH THE SUPERB SCIENTIFIC WORLD OF PATHOLOGY

Exploring Intrapolations

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Universiti Putra Malaysia Press
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Selangor Darul Ehsan

Tel: 03-89468851/89468854
Fax: 03-89416172
Email: penerbit@putra.upm.edu.my
Website: www.penerbit.upm.edu.my

ISBN: 9789673446384

INAUGURAL LECTURE series

Professor Dr. Noordin Mohamed Mustapha

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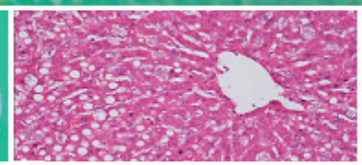

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PROFESSOR DR. NOORDIN MOHAMED MUSTAPHA

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30 September 2016

Auditorium
Fakulti Perubatan Veterinar
Universiti Putra Malaysia

Universiti Putra Malaysia Press
Serdang • 2016
http://www.penerbit.upm.edu.my

First Print 2016

UPM Press is a member of the Malaysian Book Publishers Association (MABOPA)
Membership No.: 9802

ISBN 978-967-344-544-8

Typesetting : Sahariah Abdol Rahim @ Ibrahim
Cover Design : Md Fairus Ahmad

Design, layout and printed by
Penerbit Universiti Putra Malaysia
43400 UPM Serdang
Selangor Darul Ehsan
Tel: 03-8946 8855 / 8854
Fax: 03-8941 6172
http://www.penerbit.upm.edu.my

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ABSTRACT

Although literally pathology can be defined as the "study of sufferings", it by no means signifies that a pathologist benefits by seeing an individual enduring pain from an ailment. In fact, many regard pathology as the turning point of life and it is usually dubbed as "The field where herein death rejoices to aid the living". Indeed, a very true slogan since pathology assists in explaining the cause and mechanism of death. Through this process of pathogenesis or pathophysiology, the outcome (between the interaction of host, environment and agent) is used to develop an effective treatment, control and prevention regime. An old branch of biological science, pathology works closely with the other "physical" components of chemistry and physics to elucidate an abnormality. The needs of these two physical science components is inevitable in explaining pathologies dealing with haemodynamics of blood flow, aerodynamics of particulates, phagocytic activity, metabolic derangements, action potential, forensic investigation and many others. In actual fact, it forms the backbone of Koch's postulate which, currently, either willingly or otherwise, is used in most biological research models. This includes that of infectious (from the novel prion to naked-eye parasites), metabolic, endocrine-based or toxic (all forms) origin. Most biomedical-based research relies on inventing a functional model of a disease or condition. This can only be conclusively verified using pathology where even failure to elicit biochemical changes by the body can be detected at either the microscopic or ultrastructural level. Currently, many regard pathology as a study of pre-disease condition where through biopsies, an effective treatment, control, prevention and a prognosis can be derived.

Furthermore, pathology at almost all levels, is the only field that can state if a change in a tissue is a lesion, artifact or post mortem effect. This is of utmost importance in both research and forensic investigation. Nevertheless, despite no changes or new

additions made in the terminologies used, it still remains valid and has kept itself abreast with developments in molecular and nanotechnological sciences. This has given rise to the birth of many newer branches of pathology that employ molecular techniques and nanotechnology in arriving at a confirmed diagnosis. In the medical context, the historic notion that pathology is involved with death or post mortem is currently irrelevant as mentioned earlier, since it has been successfully exploited to detect states of pre-disease conditions.

Likewise in research, pathology is not just a tool but rather an inevitable adjunct for excellence where a postulated functional model is being proven. Indirectly, while known to be associated with a non-living soul, a pathologist is an indispensable research partner in many of today's research. This review will try to illustrate the significance of the meandering path taken by pathology in the ever changing world of research and diagnosis. Examples used will be those encountered in our quest to solve problems in toxicology, forensics, environmental pollution, emerging and re-emerging diseases and the development of new nutraceutical products. It is clearly discernible that pathology was, is and will still remain as an important component in most biological science research as will be exemplified in this review.

Pathology has helped many to achieve breakthroughs in toxicology, forensic science, environmental issues, nutraceutical and transboundary disease investigations. In Brachiaria decumbens toxicity, the mechanism of liver damage and associated signs were elucidated. The use of pathology in forensic investigation attempted to estimate the time of death following the advent of virtopsy in the veterinary field. It was found that the air pollutants, especially that of PM2.5, can lead to acute and chronic changes in the lung while garlic and blackseed can alleviate these changes. Zerumbone is an effective compound that could reverse artheroscelerotic changes.

Keywords: pathology, toxicology, forensic, virology, haze, emerging & re-emerging disease, nutraceuticals

INTRODUCTION

Pathology is a study of the morphology and function of an injured tissue, organ or system as opposed to that of anatomy and physiology. Pathology, in the sense of morbid anatomy and morbid histology, is the study of alterations which develop as a result of pathogenic aetiologies or agents. Structural changes are called lesions while the genesis of this abnormality is known as pathogenesis (pathophysiology). The public at large tend to regard pathology as a state at the moment of death and equate it to an autopsy.

Unfortunately, reaction of a tissue in an injury is not a state but a process, ever changing in its manifestations. It is a process that may end in death or recovery, which may be acute or fulminating in its manifestations. The component of a **pathogenesis** comprises the dynamics of interaction between the **agent** (aetiology), **host** and **environment**. The aftermath of the deleterious interaction is manifested as a clinical sign. **Diagnosis** on the other hand is the process of tracing the aetiology of a disease or condition via the clinical signs and lesions. Thus, the signs and its related biochemical derangement (from blood or plasma) are **intrapolated** parameters which at times are still in a state of uncertainty. However, by **exploring** the tools of pathology, usually that of cellular or ultrastructural level (samples can be obtained either through biopsy or autopsy/necropsy), not only can the likelihood of an agent be determined, but also the possible pathogenetic mechanisms explained.

Finally, Thompson (1984) states that "*We must concern ourselves with the process that have got out of place, out of time and out of tune as well as with the order of structure, for disease may be defined as merely a summation of chemical reactions that have gone wrong. It is the high function of the pathologist not merely to*

attach labels to the lesions when it is seen, but to reconstruct the course of events from the earliest inception of the disease to the final moment".

The question is now how all these are related to research or how pathology can serve as an adjunct to research excellence. As in most biological research, especially those in the field of medicine and pharmacy, a functional model of the disease has to be developed without which, the research effort will be made futile and the findings null and void. This developed model needs to be verified as valid and correct, which in no other way is endorsed via pathology. This review will try, at its very best, to bring the reader into the superb wandering world of pathology that has over the years assisted many research explorations to the targeted success.

It will be incomplete if the hidden messages like that in any other disciplines on life and living are not mentioned. Spiritually and socially, disease events described and explained in pathology can be used towards the betterment of life now and thereafter. To be fascinated by how the body makes use of pathology weaponry to adapt itself by suiting needs during a crisis, will bring one closer to the Creator. At each and every moment, the body's arsenal is put on an alert state of preparedness. Any trigger alarming harm will incite an effective proper action, like a call for inflammation when exposed to a foreign agent. This can be utilised in daily life when an occasion arises for an appropriate action, to achieve maximal effect within a short period of time, i.e to tactfully handle issues or crises. If inflammation is equated to war, then one would always refrain from insulting others. If it needs to defend itself, as the ultimatum of inflammation, it would be restoration to normal or back to the original state, but without taking what is not needed or that which does not belong to the defending host.

MEANDERING THROUGH THE WORLD OF TOXICOLOGY: *BRACHIARIA DECUMBENS* TOXICITY IN SHEEP

Insufficient intake and utilisation of nutrients from available local feed resources contributed to the poor production performance of small ruminants, leading to a sluggish industry in Malaysia (Noordin, 1996). Success in economically ultilising very nutritive and highly productive grasses such as *B. decumbens* and/or their by-products is believed to be able to solve this problem. Considering the significance and pertinent concerns mentioned about the sad slothful ruminant industry, it is possible to exploit *B. decumbens* advantageously without serious health risks if the toxic constituents and pathogenesis involved are fully understood and thus pragmatic measures can be proposed.

Unfortunately, *B. decumbens* toxicity is a setback to jumpstart the sluggish ruminant industry (Briton and Paltridge, 1940). It is a condition similar to hepatogenous photosensitisation syndrome (HPS) in small ruminants that has been reported globally (Assumaidaee *et al*., 2010; 2012). In general, salient clinical signs such as jaundice (Figure 1A) and photosensitization (Figure 1B), submandibular oedema or bottle-jaw (Figure 1C) with pathologic evidence of hepatic necrosis (Figure 2A and 2B) and crystal-like clefts (Figure 2C) in affected hepatocytes and the bile ductular system were observed in natural and experimental cases of *B. decumbens* intoxication (Abas *et al*., 1985; Noordin *et al*., 1989; Graydon *et al*., 1991). Occasionally, renal damage in the form of acute tubular necrosis (Figure 3) is seen, leading to the initial believe of excessive copper involvement (Noordin et al., 1987). However, the role of copper was later nullified based on onset, tissue copper and lesion distribution concentration. The metabolite/s of the toxin while in the act of being excreted through the urine is itself

toxic to the kidneys (Zhang et al., 2000; 2001; Assumaidaee et al., 2010). Nevertheless, physiologically it was found that ruminal stasis (Figure 4) occurred although it could be partially attributed to anorexia (Abdullah et al., 1988) or the toxins, or both.

The mechanisms related to the pathogenesis, including the retention of photodynamic pigments and liver damage in HPS by toxic principles, remained unanswered since the forties (Briton & Paltridge, 1940) before being partially elucidated (Noordin, 1989). The HPS that is clinically manifested as icterus, photosensitisation and occasionally haemoglobinuria, is considered as liver based poisoning in small ruminants (Noordin, 1989; Zhang et al., 2000; Zhang et al., 2001; Assumaidaee et al., 2010). Sporadic outbreaks of this syndrome are commonly associated with grazing of certain plants, although there is considerable discrepancy in relation to the reported aetiologies in different regions.

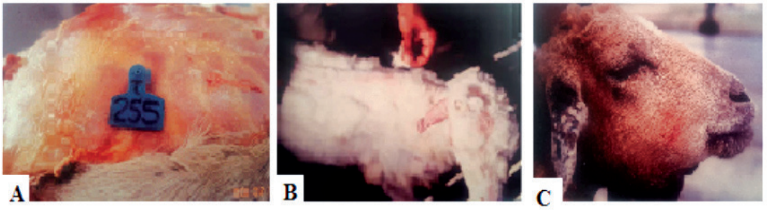

Figure 1 Photograph of typical signs and lesions seen in *Brachiaria decumbens* toxicity. (A). Jaundice of serosal, mucosal and subcutaneous tissue as evidenced by marked yellowing of affected tissue. (B). Photosensitisation usually affecting lightly pigmented skin of the dorsum, ears and face which may lead to depilation of wool. (C). Submandibular oedema also known as bottle-jaw is manifested as a result of hepatic failure (hypoalbuminaemia).

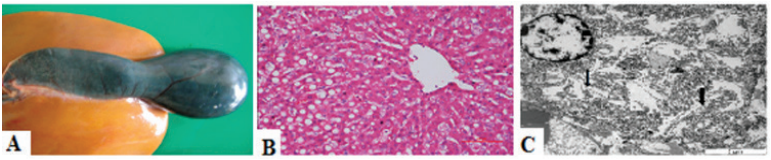

Figure 2 Post mortem observation of the affected liver shows discernible lesions at the gross, microscopic and ultrastructural levels. (A). Photograph of an affected liver shows marked icterus. (B). Photomicrograph of the liver histology depicts an admixture of fatty degeneration and necrosis without a specific lobular pattern (H&E, X200). (C). Electronmicrograph of the liver exhibits the presence of cholesterol-like clefts (arrows).

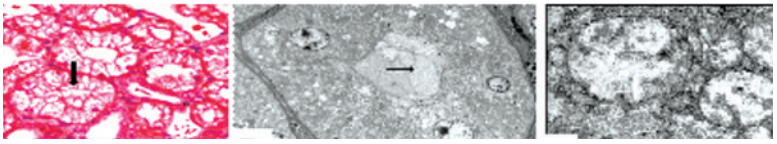

Figure 3 The changes in the kidney, as that of the liver, can be seen at gross, microscopic and ultrastructure levels. (A). Photomicrograph of the kidney depicts severe tubulonephrosis (H&E, X200). (B). Electronmicrograph of the affected kidney reveals proximal tubular epithelium microvilli desquamation along with shedding of globules of various sizes into the tubular lumen (arrow). (C). Ultrastructurally, mitochondriopathy, characterised by mitochondrial swelling, cristolysis and cristorrhexis, is seen in the affected tubular epithelium.

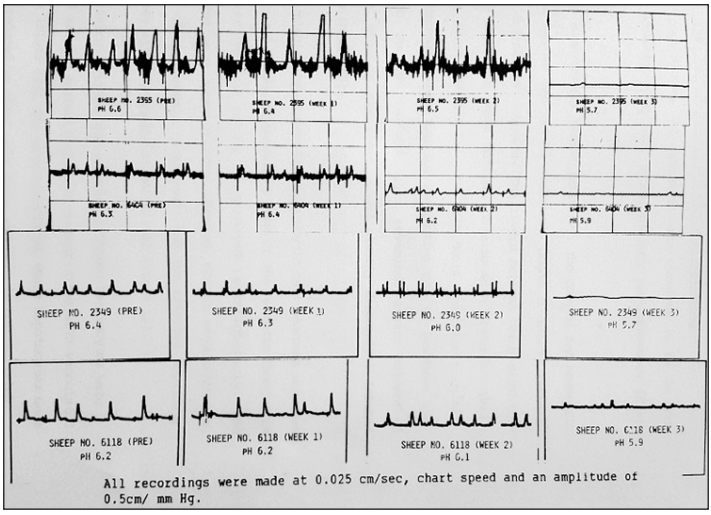

Figure 4 Photograph of a physiogram on ruminal peristalsis recording detects progressive stasis and a drop in pH towards the end of the toxicity trial.

Saponins and/or unknown toxins within those plants, with or without mycotoxins, have been speculated to contribute to the development of HPS. However, the mycotoxin theory involvement in *B. decumbens* toxicity was later scientifically dismissed by Abas-Mazni et al. (1988) following failure to elicit toxicity using fusty grass. Abas-Mazni et al. (1988) have thus paved an easier, faster and economically viable means for researchers to focus on other possible agent/s and mechanisms involved in this toxicity (Noordin, 1989).

Although the finding of Abas Mazni et al. (1988) have greatly assisted future researchers to ignore the role of mycotoxins in their pursuit of explaining this toxic mechanism, the mystery of the toxic principles or parent compounds involved in *B. decumbens* intoxications still continue to affect mainly sheep, along with an unclear pathogenesis. Consequently, no practical means of

prevention have been proposed for this intoxication since the toxic principle and its pathogenetic mechanism remains unanswered.

The suggestion to eradicate this grass is rather impractical, not only in terms of the acreage involvement and high cost, but as it would also be a great loss due its highly nutritious yield. The best pragmatic approach is to utilise the grass with the absence of or with minimal toxic effects. However, no definite conclusion can be drawn on how this would be possible (Noordin, 1989). The only partially pragmatic approach in the prevention is either rotational grazing in combination with other grasses or complete avoidance of feeding this grass to small ruminants (Noordin, 1989; Abdullah et al., 1989; Zhang et al., 2000). On the other hand, the other enigma of this toxicity is that cattle (at least) in Malaysia are not clinically affected (Noordin et al., 1989).

It was then hypothesised that *B. decumbens* intoxication could be caused by the constituents present in the grass which will later be metabolized in the rumen into hepatotoxic components, leading to HPS (Noordin, 1989). The discrepancy between the ruminal microflora population in cattle and sheep would also account for their differences in susceptibility. The first hypothesis postulated by Noordin (1989) as seen later, was proven to be true in two later findings (Abdullah et al, 1989; Lajis et al., 1993; Zhang et al., 2000).

This warranted a much more comprehensive research based on the hypothesis that the toxin is formed in the rumen of sheep following ingestion. Studies were then carried out to elucidate the aetiology and pathogenesis of *B. decumbens* intoxication in sheep in Malaysia, aimed at ending the shrouded mystery, with the following objectives:

- to determine possible anti-nutritional compounds present in the grass that may exacerbate toxicity;

- to determine the role of lipid peroxidation and anti-oxidant status in generating hepatic damage in *B. decumbens* intoxication;
- to correlate the pathological change, free radical metabolism and mineral interaction in the development of *B. decumbens* intoxication;
- to elucidate the effects of Cu and Zn administration in the development of *B. decumbens* intoxication;
- to isolate and characterise the toxic principle/s that is/are involved in *B. decumbens* intoxication; and
- last but not least, to explain why cattle are not affected by this toxicosis (at least in Malaysia).

Thus, all studies conducted were aimed at elucidating the pathogenesis which in turn would lead to better understanding of the disease and provide pragmatic strategies in treating and preventing *B. decumbens* intoxication.

Possible Anti-nutritional Compound Exacerbating *B. decumbens* Toxicity

Experiments were conducted to obtain a baseline value of mineral and phytate levels in *B. decumbens*, the effect of feeding *B. decumbens* to sheep, the role of copper (Cu) in *B. decumbens* intoxication, the effectiveness of zinc (Zn) and its role in the prevention of *B. decumbens* intoxication.

Samples of *B. decumbens,* collected from five different farms representing Peninsular Malaysia, were air-dried, milled and analysed for concentrations of selected minerals and phytate. It was found that the molar ratios of Cu:Zn, Cu:Mo and Cu:Fe were low and this suggested that Cu deficiency *per se* and not toxicity could be involved in the toxicity of *B. decumbens*. Furthermore,

this low ratio of the trace mineral might aggravate the development of photosensitization in unpigmented or lightly pigmented areas of affected animals. Likewise, the Zn:phytate ratio could predispose to Zn deficiency during intoxication (Noordin et al., 2000).

Aetiology of *B. decumbens* Toxicity: Isolation and Characterization of the Toxic Compound/s

Studies on the isolation and characterisation of the toxic compound yielded a diosgenin (Figure 5). Toxicity test of diosgenin from *B. decumbens* in mice indicated a LD_{50} of 410.5 mg/kg which by calculation conforms to a similar dosage in sheep (Zhang et al., 2000; 2001).

Based on the results from studies conducted (Zhang et al., 2000), the postulated pathogenesis of this intoxication was then successfully verified. This again proved that the earlier hypotheses of Noordin (1989) and those of Abdullah et al. (1992) and Lajis et al. (1993) were true.

These findings solved the enigma that had surrounded the aetiopathogenesis of HPS for more than 50 years (Noordin, 1989; Zhang et al., 2001). Additional data on *B. decumbens* toxicity includes findings of severe neurological dysfunction observed in sheep 4 weeks after grazing on *Brachiaria decumbens*. These neurological disorders included the stamping of forelegs, star-gazing, incoordination, head-pressing against the fence and circling movements. Histologically, numerous vacuolations of various sizes were observed in the white matter of the brain, giving rise to a spongy appearance (Abdullah et al., 1989).

Pathogensis of *B. decumbens* Toxicity

The toxic constituents present in *B. decumbens* may enhance lipid peroxidation of the cell membrane and impair the antioxidant system. The progression of *B. decumbens* intoxications can be exacerbated by Cu supplementation *via* a proposed synergistic interaction between free ionic Cu and essential membranous macromolecules. The development of *B. decumbens* intoxication can be partially prevented by the administration of zinc (Zn), due to its stabilising effects on macromolecular components in membranes. An attempt was made to clarify the association between zinc (Zn) and antioxidants due to Zn supplementation on lipid peroxidation occurring during *B. decumbens* intoxication (Zhang et al., 2001). The concentrations of Zn, copper, malondialdehyde (MDA), superoxide dismutase (SOD) and gluthathione peroxidase (GSH-Px) were thus determined in tissues. It was seen that there was a gradual increment in the concentration of Zn and MDA in serum and hepatocytic SOD in groups given Zn plus *B. decumbens*. A decline in erythrocytic GSH-Px and SOD, and lower concentration of reduced glutathione in hepatocyte cytosols, were also detected in these sheep. It is thus highly suggestive that Zn supplementation may depress antioxidant status and enhance lipid peroxidation during *B. decumbens* intoxication.

Tolerance of Cattle to *B. decumbens* Toxicity

Although *B. decumbens* was not toxic when fed to cattle (Noordin et al., 1988), the infusion of rumen liquor from *B. decumbens* intoxicated sheep into the rumen of cattle produced evidence suggestive of hepatic and renal dysfunction. Several biochemical changes were observed, including increases in serum aspartate amino transferase, serum creatinine and blood urea nitrogen and a

marked reduction in the plasma bromosulphthalein clearance. This further supported the earlier hypothesis of ruminal metabolism of *B. decumbens* in ovines developing into toxic compounds.

Aetiopathogenesis of *B. decumbens* Toxicity in Sheep

Following these findings, this well adapted grass(to a wide range of well-drained soils including humid tropic soils) that has been extensively planted in almost all government farms in Malaysia could be ultilised with minimal toxic incidence.

Figure 6 outlines the likely aetiopathogenesis of *B. decumbens* toxicity in sheep. Basically, following ingestion, the disogenin from the grass is metabolised by the ruminal microflora. Then, after uptake by hepatocytes, the sapogenin and its metabolites are biotransformed into epi-similagenin and epi-sarsapogenin (Figure 5). This process is catalysed by the mixed function oxidases system, yielding intermediate free radicals. It is likely that at this point, the hepatocytes began to cause damage, at both cellular and subcellular levels. The damage is due to membrane lipid peroxidation leading to interference in the transport and excretion of endogenous metabolites which in turn lead to jaundice and photosensitisation.

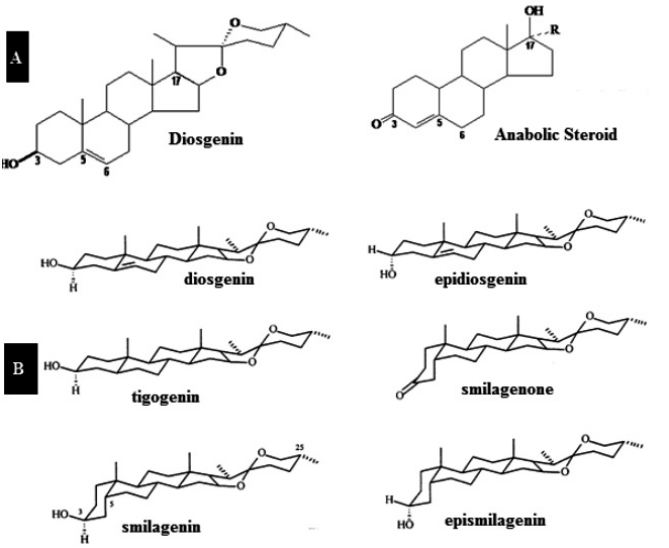

Figure 5 The compounds found in *B. decumbens* and their analogues following ruminal and hepatic metabolism. A. The chemical structure of diosgenin as compared to anabolic steroid. B. The chemical structures of the B. decumbens analogue that is formed once ingested by sheep.

MEANDERING THROUGH THE WORLD OF FORENSICS: ESTIMATION ON TIME OF DEATH

The quest for what transpires at post-mortem in relation to time-dependent changes in an organism spawned the interest to utilize pathology to understand these processes. A variety of methods have been employed to determine rates of carcass decomposition which are of interest in the investigation of cause and manner of death in routine veterinary necropsy practice. Such estimates of post-mortem decomposition rates are often not admissible in courts as they are devoid of strong

research basis for statistically significant general conclusions on the processes.

These methods include algor mortis (post-mortem body cooling), rigor mortis (post-mortem muscle stiffening), livor mortis (colour changes due to gravitational force) and putrefaction (changes in odour) which comprise the most conservative of post-mortem interval estimation methods. Advances in forensic research have revealed that events occurring after death are much more complex than earlier assumed, even as some of these events are time-dependent. Further intense study is thus required to link post-mortem intervals with post-mortem physical, biochemical, pathological and genetic changes that occur, for forensic purposes.

Our investigations, with the aid of a background in pathology, led us to utilize various understandings of the pathological processes to grasp the interplay between time and post-mortem organismal changes. Methods used ranged from conservative ones, such as, algor mortis – using thermocouples and mercury bulb thermometers, to high throughput microarray whole genome expression.

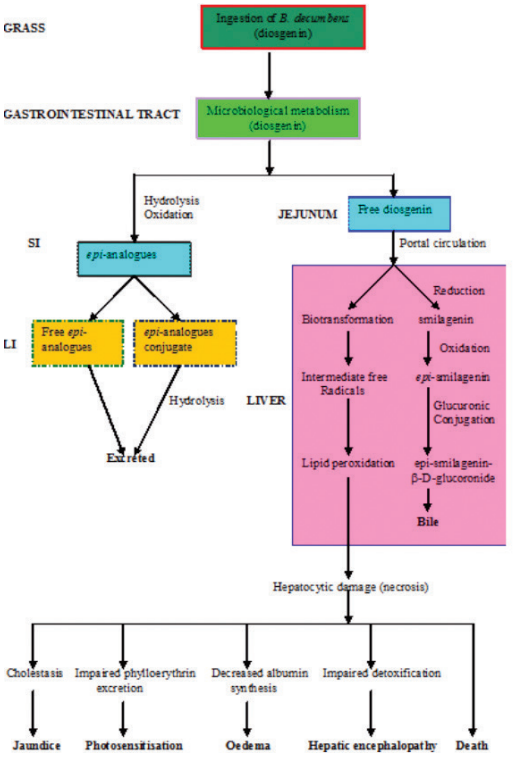

Figure 6 The aetiopathogenesis of *B. decumbens* intoxication in sheep with particular emphasis on the liver. (LI = large intestine; SI = small intestine)

Algor Mortis

Post-mortem body cooling (algor mortis) is a well-known phenomenon to pathologists. The heat loosing mechanism of organisms after death depends on the body heat at the time of death as well as the manner of death, whether it is natural or unnatural. Heat is generated physiologically through metabolic processes

ante-mortem as well as from musculoskeletal movements and contractions peri-mortem. The amount of core body heat thus generated affects the rate of algor mortis. Algor mortis has been used for forensic purposes in order to estimate time of death, especially in criminal investigations involving humans. Algor mortis is currently considered to be more reliable in PMI estimation in comparison to other methods such as biochemical changes, cell death rate (necrosis), electrical alterations and electrolyte changes and bioamines distribution.

Henssge (1988) was the first advocate of the use of algor mortis for PMI estimation for which he developed a normogram for field use by the police. He observed that in temperate climates, despite the cool ambient temperature, there is usually a lag phase in the rate of drop in body temperature that resembles a plateau when plotted on a graph. Hence this was called a "post-mortem plateau". This finding was of importance in that it was not in consonance with the long held assumption that body cooling follows the Newton's law of thermal conductivity of matter which was thought to be at a rate of 1.5°F per hour.

It was expected that in tropical climates such as in Malaysia, where ambient temperatures often matches that of the core human body temperature, algor mortis would maintain such a plateau or even spike transiently (Kaliszan, 2012). Contrary to anecdotal expectations, we discovered that in Malaysia, neither the plateau nor the spike existed (Figures 7-9) at post-mortem in dogs (Abdulazeez & Noordin, 2010). The temperature drop per unit hour (Table 1) followed a strongly exponential pattern with an R value of 0.91 as represented by the equation:

$t = -8.47 \ln([T_r - T_a]/13.5)$ ..... I (Rectal model)

$t = -10.42 \ln([T_h - T_a]/12.33)$..... II (Hepatic model)

Where T = temperature of any organ at any point in time post-mortem

T_a = average ambient temperature (27°C)

a and b = coefficients derived from curve fit

t = time of death

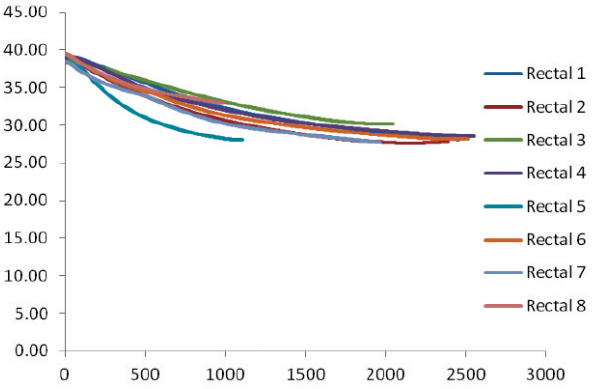

Figure 7 The pattern of drop of post-mortem rectal temperature over twenty-four hours

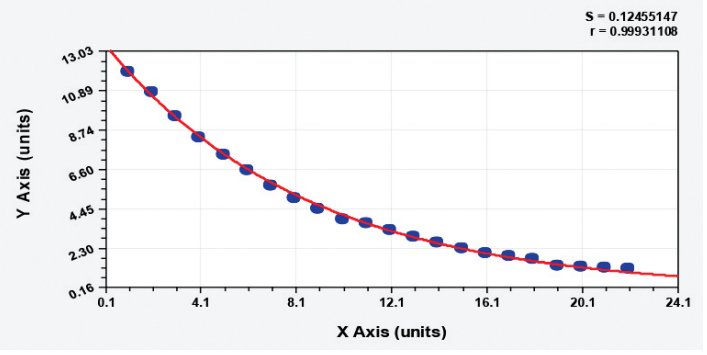

Figure 8 The curve-fit model for the average temperature differences (T_r - T_a) for the rectum, also showing the standard error and correlation coefficient values. X axis is time (hours) and the Y axis is the T_r - T_a

(°C).

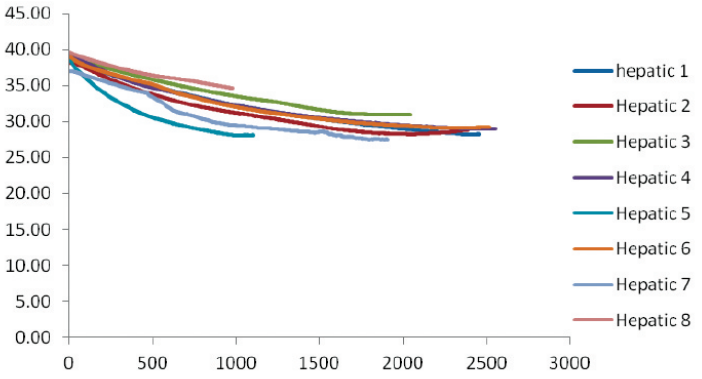

Figure 9 The pattern of drop of post-mortem hepatic temperature over twenty-four hours

Table 1 The rates of drop per hour of post-mortem temperature for organs over twenty-hours

	Organ	
Animal ID	**Rectal**	**Hepatic**
1	0.537	0.523
2	0.532	0.533
3	0.513	0.451
4	0.560	0.475
5	0.527	0.452
6	0.539	0.487
7	0.660	0.603
8	0.520	0.305
Mean ± SD	**0.55±0.05**	**0.48±0.09**

The absence of the post-mortem plateau is important in understanding the context of the use of Henssge's nomogram in veterinary forensic practice. It was observed that the nomogram was valuable for use in subjects heavier than 10kg, even as the correction factors used for humans may not be applicable for use in animals (Henssge, 1988). We thereby came up with a pragmatic equation model for field use (Abdulazeez & Noordin, 2010).

We investigated this phenomenon in smaller-sized animals (Sprague-Dawley rats) using thermography. Aside from the absence of a plateau in this species at room temperature, our study revealed that heat dissipation occurred at different rates for different body parts. The limbs and the tail lost heat most rapidly in contrast to the abdominal region that slowly lost heat over an 8 hour period.

Table 2 The coefficients a and b for organs with 95% lower and upper confidence bounds

Organ	a (95% CI)	b (95% CI)
Rectal	13.5 (13.26, 13.74)	-0.118 (-0.358, 0.122)
Hepatic	12.33 (11.84, 12.82)	-0.096 (-0.586, 0.394)

Post-mortem Radiography

The process of carcass/cadaver decomposition begins immediately in tissues that are cut short of oxygen supply. Necrosis and putrefaction takes effect leading to production of gas by-products (methane, hydrogen sulphide and many more) and odoriferous changes. The gas production is a result of bacterial colonization of tissues following the death of an animal. These gases result in the swelling of luminal organs such as the stomach (bloating) and intestines and can be observed by radiography as radiolucent opacities within the tissues. Previous studies established the ability

of 2D-radiography to identify these gaseous changes but limited reference was made in those studies about the correlation between post-mortem gas formation and post-mortem interval (Abdulazeez and Noordin, 2016). We therefore conducted a study to determine the progression of post-mortem gas formation in luminal organs with a goal to identify an alternative means of estimating PMI using imaging modality for routine clinic practice. We found that the cardiac chambers accumulated gas in a manner reflective of post-mortem intervals (Figure 10). The right atrium accumulated gas as early as 6 hours post-mortem followed by the right ventricle, left atrium and finally the left ventricle, over a period of 24 hours (Abdulazeez and Noordin, 2014).

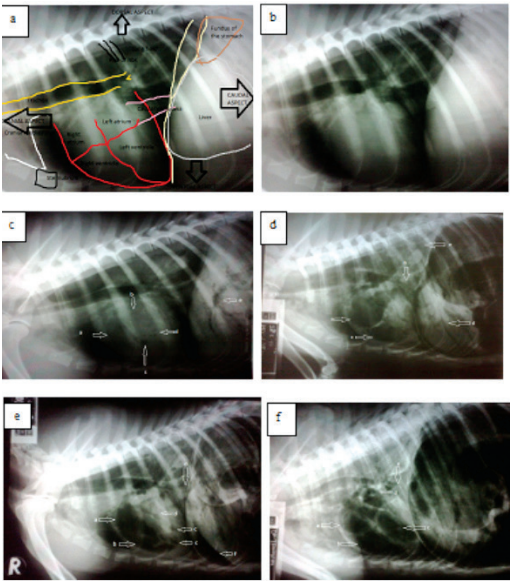

Figure 10a-f Radiograph showing schematic outline of the thorax (a) and serial progression of post-mortem gas formation in the thorax and cardiac chambers of dogs (b – f) at early (24 hours) post-mortem interval.

Whole Genome Expression

Pathology involves the study of changes in structure and function of cells, tissues, organs and systems. At death the myriad of events that initiate the post-mortem decomposition process is still a subject of intense research. Studies have shown that genetic materials such as the deoxyribonucleic acids (DNA) and ribonucleic acids (RNA) of human and some animals continue to be active for a while even after death (Kayser & Knijff, 2011).

We investigated the concentration and purity of RNA in dogs to compare the rate of RNA degradation (Figure 11) with the post-mortem interval. Our findings revealed no correlation because RNAs are largely unstable at post-mortem but are very valuable for high throughput studies such as microarray whole genome expression (Table 3) analysis (Abdulazeez, 2011).

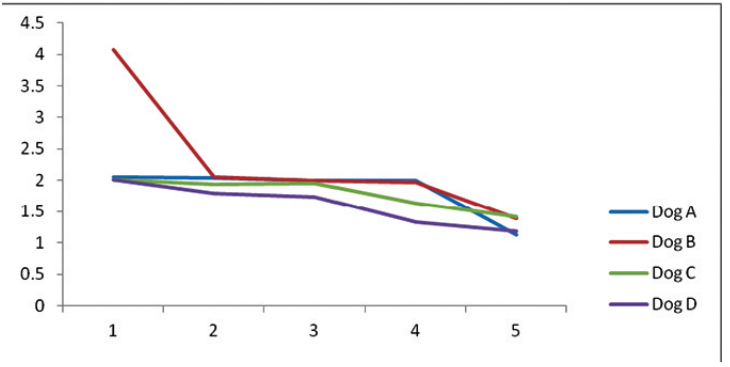

Figure 11 The graphical representation of the downward trend of RNA optical density values over time as PMI lapses.

Serial post-mortem microarray gene expression analyses (Table 3) revealed regulation (up or down) patterns involving genes associated with cell death and physiologic regulatory functions (Abdulazeez, 2011). Findings in this study have opened up the gates to questions hovering around the scientific definition of death.

Table 3 The expression profile of selected genes over a thirty hour PMI period

Gene name	Animal	Fold changes			Trend
		A	C		
		20^{th}	10^{th}	20^{th}	
Beta-Actin	ACTB*	1.04	2.21	1.16	Mixed
Beta-2-microglobulin	B-2-M*	1.2	1.88	1.19	Mixed
Glyceraldehyde-3-phosphate dehydrogenase	GAPDH*	1.13	1.89	3.29	Decrease
Ribosomal protein L8	RPL8*	1.68	2.18	1.92	Decrease
Ribosomal protein S18	RPS18*	4.32	2.03	3.19	Decrease
TATA Box binding protein	TBP*	1.19	2.19	3.94	Mixed
Succinate dehydrogenase subcomplex unit A	SDHA*	5.1	13.36	6.89	Decrease
Adenosine deaminase	ADA	2.13	2.00	6.65	Decrease
Calmodulin 1	CALM1	2.83	4.8	13.44	Decrease
Calmodulin 3	CALM3	1.93	2.26	2.42	Increase
Death factor CD95	DFCD95	7.39	17.51	16.92	Increase
Defender against cell death 1	DAD1	4.47	5.86	2.9	Decrease
Hypoxia inducible factor 1A	HIF1A	10.16	25.88	2.05	Increase
Lactate dehydrogenase D	LDHD	3.87	6.9	10.12	Increase
Malate dehydrogenase	MDH	4.34	8.9	4.2	Decrease
Obscurin	OBSCN	41.8	17.2	8.7	Increase
Ornithine decarboxylase antizyme 2	OAZ1	3.36	5.76	9.81	Mixed
Programmed cell death 2	PDCD2	19.86	4.77	2.09	Decrease
Spermidine synthase	SPDSY¶	8	3.7	6.3	Mixed

MEANDERING THROUGH THE WORLD OF VIROLOGY: PATHOGENESIS OF BOID INCLUSION BODY DISEASE

Boid inclusion body disease (BIBD) is a disease of snakes from the boid (constrictor) family, which encompasses the python, boa and anaconda. The disease has been discovered in several boid snakes including the boa constrictor (*Boa constrictor*), green anaconda (*Eunectes murinus*), Haitian boa (*Epicrates striatus*), ringed tree boa (*Corallus annulatus*), garden tree boa (*Corallus hortulanus*), Burmese python (*Python molurus*), reticulated python (*Python reticulatus*), ball python (*Python regius*) and Australian python (*Morelia spilota variegate and Morelia spilota spilota*) (Ilyasu, 2016). Colloquially, the disease is coined as the "Twister" due to the failure of the affected snakes to right themselves. The affected snakes may twirl in a vertical position or their bodies may become abnormally twisted.

Until recently, retroviruses and paramyxoviruses have widely been suspected as the causative agents as they were frequently isolated from tissue samples of positive snakes, a claim that was later discountenanced, as these families of viruses were later recognized as being endogenous to these snakes and were also frequently isolated from genome sequences of negative snakes as well (Chang and Jacobson, 2010). Most recently however, two novel arenavirus genomes were detected while another two were isolated from tissues of snakes histologically diagnosed as being positive for the disease and have been confirmed to be the causative agents (Ilyasu et al., 2015a). This new development increased the research interest on the disease investigation as all regions of the world had reported the detection of arenavirus in snakes with BIBD, except South East Asia and Asia Pacific.

The clinical signs are often variable, with regurgitation commonly observed as the first indication of the disease, followed by anorexia. The affected snakes may show central nervous system disorders, such as head tremor and opisthotonus, commonly observed as twisting (Figure 12). Dysecdysis or abnormal skin shedding frequently occurs as a result of the partial paralysis of the posterior half of the snake (Chang and Jacobson, 2010).

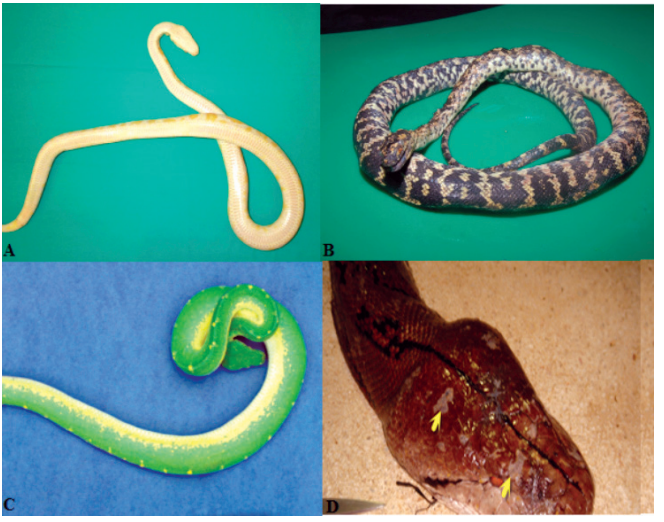

Figure 12 Photographs of BIBD infected boids. (A) An albino python, (B) reticulated python and (C) green tree boa exhibit nervous dysfunction giving rise to the classical clinical signs of twister. (D) Close-up view of a reticulated python with abraded-like skin lesions due to dysecdysis.

Death may occur from secondary bacterial, fungal and protozoan infections. Other non-specific clinical signs include encephalitis, pneumonia, hepatitis, enteritis and osteomyelitis. Both the clinical manifestations and the disease progression differ

in boas and pythons, where while the disease can run an acute or chronic course in some affected species, boas die within weeks or months with less frequent manifestation of nervous signs, or become asymptomatic carriers. Pythons on the other hand were shown to suffer mostly from an acute form of the disease, with an overt clinical manifestation of a severe fatal nervous involvement (Ilyasu et al., 2015; Ilyasu, 2016).

Until recently, the most rapid diagnostic technique for BIBD was through the detection of intracytoplasmic inclusion bodies in the peripheral leucocytes, which was considered the gold standard for the diagnosis of BIBD. Biopsy samples from organs such as the liver, kidney and spleen often proved valuable for early and successful detection of inclusion bodies (Figure 13) (Ilyasu, 2016). The inclusion bodies were found to be made up of a protein that has a molecular weight of 68kDa (Wozniak et al., 2000; Ilyasu et al., 2015a). As the pathogenesis is unclear to scientists, the disease remains a mystery, hence there is no drug for its treatment and no vaccine available for its prevention (Chang and Jacobson, 2010; Ilyasu, 2016). Evidence available suggests that the disease can be transmitted among snakes, but the exact modes of transmission are still not understood. However, the blood sucking snake mite *Ophionyssus natricis* have frequently been associated with snake collections during outbreaks and may therefore be acting as a vector (Chang and Jacobson, 2010).

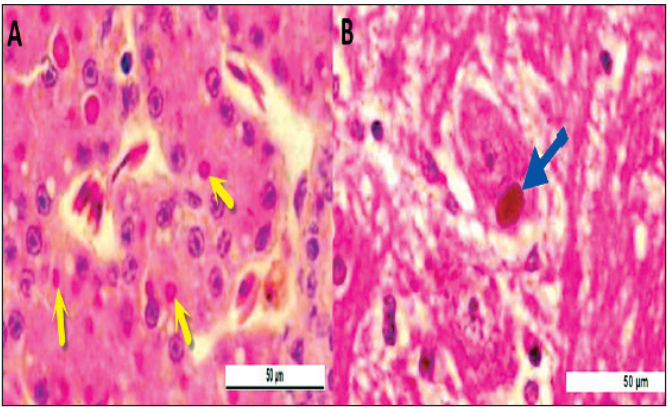

Figure 13 Histological section of the liver (A) and brain (B) from a snake with BIBD showing numerous eosinophilic intracytoplasmic inclusion bodies (H&E, X 200)

In Malaysia, the first suspected case was reported in 2008 at a large snake enclosure. Although at that time it was believed to be caused by a retrovirus, these reported cases were the first to be reported in South East Asia and Asia Pacific and were presented as a case of retrovirus infection (Noordin et al., 2008).

Later, further microscopic and ultrastructural investigations along with virus isolation with *in vitro* and in *vivo* model studies were mounted to explain the outbreak and possible pathogenesis (Ibrahim, 2013).

Ibrahim (2013) was able to establish the presence of eosinophilic intracytoplasmic inclusion bodies in the tissues of the infected snakes. Similarly, the cytopathologic effect of the virus was shown in Vero and rat embryonic fibroblast cell lines [REF] (Figure 14), characterized by vacuolations, cell sloughing and complete destruction of cellular monolayers.

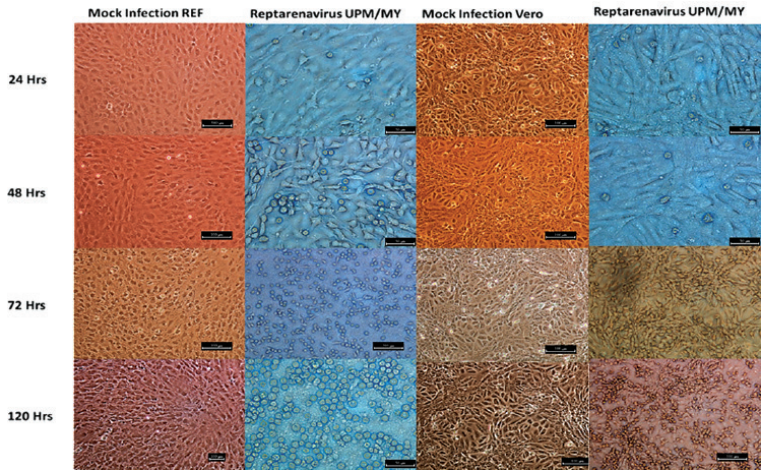

Figure 14 Photomicrograph of the REF and Vero cells inoculated with the reptarenavirus. Evidence of viral cytopathic effect in REF and Vero cells infected with reptarenavirus UPM/MY is seen as cell rounding in REF cells at 48 hours and 72 hours in Vero cells.

In the laboratory animal model (mice), evidence of organ and tissue pathology was observed after inoculation of virus suspensions from infected pythons and boas (Figure 15). These include degeneration and necrosis in the kidneys; congestion, interstitial pneumonia and emphysema in the lungs; and congestion and edema in the brain. Hepatocytic degeneration and necrosis with reactive germinal centers were also seen in the spleen. Haematological changes induced by the virus include leucopenia, neutropaenia and thrombocytopaenia during the sub-chronic course. Furthermore, the virus was successfully re-isolated in cell cultures from the organs of infected mice (Ibrahim, 2013) proving the Koch postulate that the incriminating agent was a virus.

Due to the dearth of knowledge on the pathogenicity of the virus, our laboratory attempted to device a simple and cheap means of preventing snakes from being infected. Since there is currently

no remedy for the virus, the effects of antioxidant compounds such as resveratrol and ascorbic acid were investigated on the viral pathogenesis in cell lines and mice animal model.

Ascorbic acid is a commonly available vitamin present in fruits, and has shown remarkable antioxidant effects (Abba et al., 2015a). Resveratrol is a stilbene derived from grapes and has also shown good antioxidant and antiviral effects against human and animal viruses (Abba et al., 2015b).

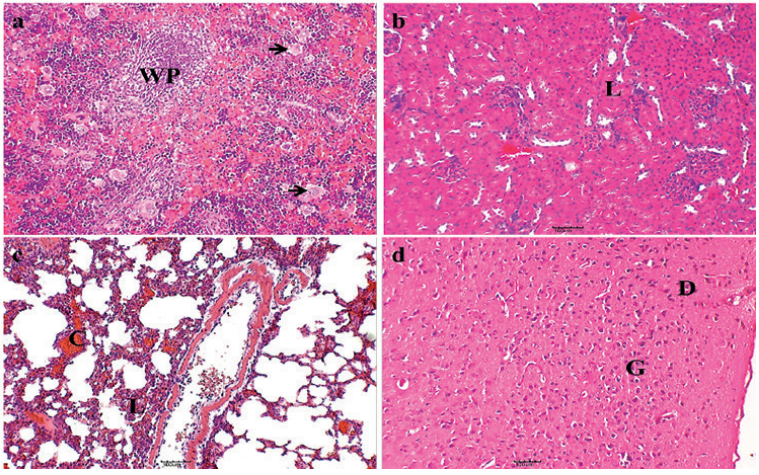

Figure 15 Photomicrograph of selected tissues following infection of mice with reptarenavirus: (a) Spleen showing depletion of the white pulp (**WP**) and fluid filled pockets (arrows) in the periarteriolar lymphoid sheath; (b) The kidney showing interstitial lymphocytic (**L**) infiltration; (c) The lungs showing mainly congestion (**C**) and interstitial lymphocytic infiltration (**L**); and (d) The brain showing a rather hypercellular appearance due to gliosis (**G**) in the cerebral cortex with the presence of red neurons indicating neuronal death (**D**) (H& E, X 200).

Investigation of the effects of these two compounds against the virus in Vero cells showed amelioration of oxidative stress by modulating oxidant and (Figure 16) enzyme levels (glutathione, hydrogen peroxide and lipid peroxidase) in treated cells when compared to the untreated cells. This showed that the compounds exhibited antioxidant effects against the virus (Abba et al., 2014). In the mice model, groups treated with resveratrol after viral infection showed less severe lesions in the lungs, liver and spleen (Figures 17-18), when compared to the untreated groups (Abba et al., 2015c).

At the same time, due to being puzzled by the intracytoplasmic inclusions, an investigation on the association between the virus and heat shock protein expression in infected snakes and the pathogenesis of the virus in chicken embryos was also conducted. The virus was shown to induce expression of heat shock protein in infected snakes (Ilyasu et al., 2015b). In addition, reptarenavirus also induced pathological lesions such as vacuolation, congestion and inclusion body formation in chicken embryos (Figure 19) which were observed in the infected embryos (Ilyasu et al., 2016). In vitro viral re-isolation in cell culture showed cytopathic effects characteristic of reptarenavirus, as previously reported by Omar (2013) and Abba et al. (2016).

In 2012, based on new evidence from next generation sequencing technology, the etiological agent of the disease was revised as being a reptarenavirus belonging to the family *Arenaviridae*. Based on this information, viral RNA of cases isolated from Malaysia was amplified using RT-PCR with primers specific for the L-segment of reptarenavirus. Sanger sequencing identified four closely associated reptarenavirus species from 15 (37.5%) of the total samples tested, and these were named: reptarenavirus UPM-MY

01, 02, 03 and 04. These isolates were phylogenetically closely related to the University Helsinki virus (UHV), Boa Arenavirus NL (ROUTV) (BAV) and unidentified reptarenavirus L20 (URAV-L20). Comparison of deduced amino acid sequences further confirmed the identities to L-protein of UHV, L-polymerase of BAV and RNA-dependent RNA polymerase of URAV-L20 (Figure 20) from Finland and the Netherlands (Abba et al., 2016). This is the first report of successful identification of the virus in South East Asia and Asia Pacific combined.

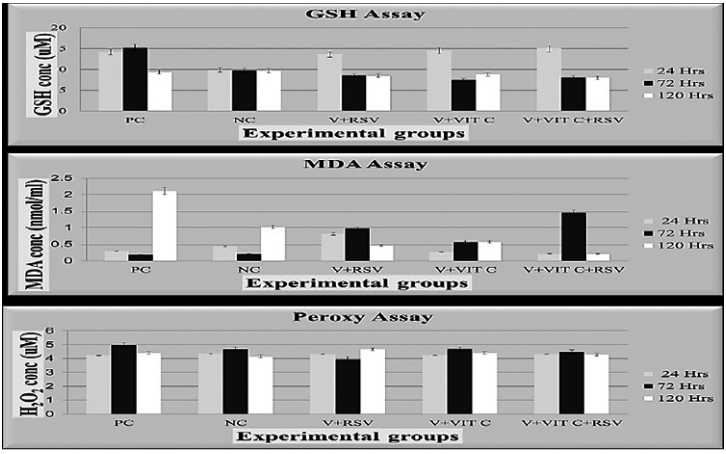

Figure 16 Bar chart of selected anti-oxidant and peroxidation status of Vero cells incubated with reptarenavirus at 24, 72 and 120 hours post-inoculation. The data indicates that oxidative stress may play a role in the pathogenesis of BIBD.

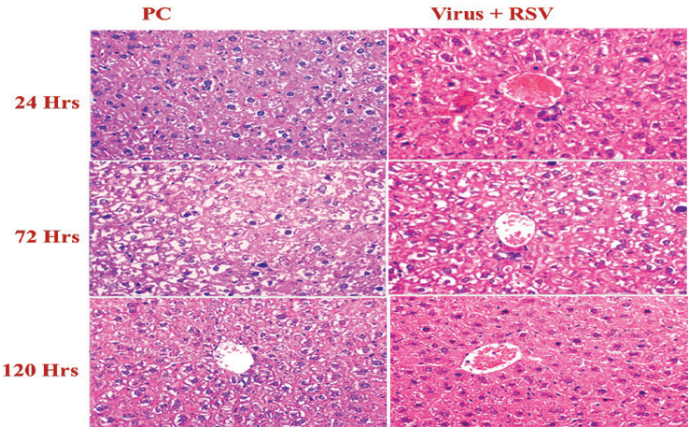

Figure 17 Photomicrograph of the liver of mice infected with reptarenavirus, with and without resveratrol supplementation, at 24, 72 and 120 hours post-infection. Histological changes of degeneration in the hepatocytes and Kupffer cells were milder in the resveratrol supplemented group (H&E, X 400).

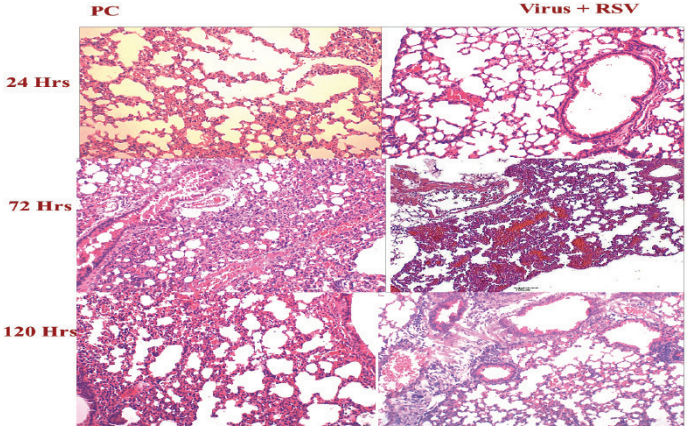

Figure 18 Photomicrograph of the lung of mice infected with reptarenavirus with and without resveratrol supplementation at 24, 72 and 120 hours post-infection. Microscopic appearance of viral infection composed of congestion and interstitial pneumonia were much milder in the resveratrol supplemented group. (H&E, X 100).

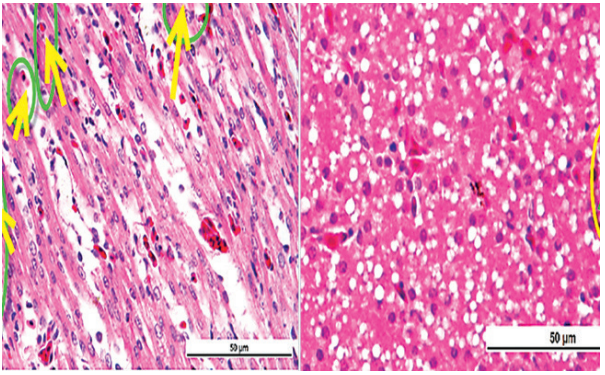

Figure 19 Photomicrograph of tissue from infected chicken embryo showing the presence of eosinophilic inclusion bodies in the cardiomyocyte (A) and liver (B). Hepatocytic vacoulations are possibly non-pathologic as this is a tissue of an embryo (H&E, X 200).

Figure 20 Phylogenetic tree of reptarenavirus UPM-MY01A-04A L-polymerase (partial) with other similar sequences from the GenBank. The tree was constructed using Geneious Software version 9.0.4(www.geneious.com) using the Jukes-Cantor, neighbor joining algorithm at 1,000 bootstrap replicates and a support threshold of 50%.

MEANDERING THROUGH WORLD OF POLLUTED AIR: TRANSBOUNDARY HAZE

Transboundary movement of atmospheric pollutants has international policy, economic, human health and environmental ramifications. Atmospheric pollutants are of particular concern since air masses flow freely across borders, leaving the geographic and political jurisdiction of the originating country and becoming the responsibility of another. Additionally, the transport of air pollutants is a significant contributor to acid rain, poor visibility, climate change and bioaccumulation of toxins in remote areas. For example, wind blown desert dust and forest fire smoke cross international borders and increase particulate matter concentrations to levels that may exceed regulatory standards and harm human health. Thus, air pollutant monitoring is an important issue for both human and environmental health on a global scale (Pope, 1996; Noordin et al., 2004).

Particulate matter (PM) has impacts on human health by reducing lung function and is of particular concern to those with an existing compromised respiratory function such as an asthmatic, children and the elderly (Wang et al., 2007a; 2007b; 2007c). Generally, PM classified as less than 10 microns, is considered inhalable, while fine PM of less than 2.5 microns, has the most impact on human health (Kim and Kang, 1997; Wang et al., 2007a; 2007b; 2007c). Particulate matter is a heterogeneous classification of liquid and solid aerosols that can remain in the atmosphere or gas stream. The PM_{10} is a particle with an aerodynamic diameter less than or equal to 10μm while $PM_{2.5}$ has an aerodynamic diameter less than 2.5μm. Particulate matter represented the major pollutant in the transmitted biomass burning emissions in Malaysia, Singapore, Brunei and Thailand (Heil, 1988).

Health effects do not only depend on the particulates as such, but also on the composition of toxic compounds adsorbed on their surface. Among these compounds are polycyclic aromatic hydrocarbons (PAH) which are formed during the combustion processes of organic material with insufficient oxygen supply (Heil, 1998). The PAH comprise of more than 100 different multi-ringed compounds of which many are known to be carcinogenic (Heil, 1998).

Increased concentrations of fine particles in the ambient air are associated with substantial health impacts, such as, acutely and chronically decreased lung function (Heil, 1998; Wang et al., 2007a; 2007b; 2007c). Accumulation of particles increases the likelihood of chronic obstructive pulmonary diseases, permanent decrease of the lung function, asthmatic symptoms and cardiovascular disease (Anon, 1998; Wang et al., 2007a; 2007b; 2007c). The acute health hazards caused by the interactions between deposited particles and the respiratory system range from acute respiratory symptoms and illness, including bronchitis, asthma, pneumonia and upper respiratory infection, impaired lung function, hospitalization for respiratory and cardiac disease, to increases in mortality (Wang et al., 2007a; 2007b; 2007c).

While breathing, particles are retained according to their size within the respiratory system. Larger particles are deposited in the upper respiratory tract, while smaller particles may penetrate deeper into the lungs, where they are retained for a longer period (Latif et al., 2009; 2010b). Inhalable particles with diameter greater than 10μm are predominately deposited in the nose, the mouth-throat area and in the larynx (Noordin et al., 2004). The resident time of the deposited particles in these areas is several hours. Particles less than 10μm in diameter may advance until the thoracic respiratory system and is mainly deposited in the trachea-bronchial area, from

where they are removed within up to 24 hours (Latif et al., 2009; 2010b). Finer particles of less than 3μm penetrate the alveolar area. The deposition probability might amount up to 60%. The elimination process of particles, which have been deposited in the alveolar area, takes between days and years (Verein, 1997; Anon, 1998; Latif et al., 2009; 2010b).

The PAH are ubiquitous products of incomplete combustion and have been found adsorbed on the particulate emissions from wood fires, pulverized coal combustion, waste incineration and laboratory scale flames (Benner *et al.*, 1990). They consist of carbon and hydrogen and can be conceived as consisting of fused rings of benzene and belong to the group of polycyclic aromatic compounds (PAC). The major concern on the presence of PAH and other PAC in the environment is caused by the fact that several of them are carcinogens and present in polluted air (Finlayson-Pitts and Pitts, 1986; Sanaz et al., 2010).

Out of a total of 11 PAH, eight were collected before, during and after the 1997 Malaysian haze episode. Eight of those have been studied in animal models at our laboratory. The eight PAHs were phenanthrene, flouranthene, pyrene, chrysene, benzo(a) pyrene, benzo(e)pyrene, indeno(1,2,3-cd)pyrene and benzo(ghi)perylene (Noordin et al., 2004; Movassagh et al., 2006; Sanaz et al., 2010; Latif et al., 2009; 2010, 2011a; 2011b). In general, almost all of these PAHs produced similar acute and chronic effects when intra-tracheally administered. In this review, the results are represented by findings seen in experiments using phenanthrene, flouranthene, benz[a]anthracene and benzo(a) pyrene (Noordin et al., 2004; Movassagh et al., 2006; Sanaz et al., 2010; Latif et al., 2009; 2010, 2011a, 2011b). Owing to the fact that once an episode of haze happens, there is nothing much we can do for the environment, there should however be ways and means of minimizing the effects on

the body when exposed to haze, for example via supplementation of herbal remedies. Thus, this triggered us to study the efficacy of readily available, cheap, non-toxic and rather specific antidotes to air pollutants (PM) such as, *Allium sativum* (garlic) and *Nigella sativa* (black seed).

Known scientifically as *Allium sativum*, garlic contains more than 100 biologically useful chemicals, including alliin, alliinase, allicin, S-allylcysteine, diallyl sulfide and allyl methyl trisulfide (Bree, 1994). The healthful properties of garlic are legion and have been identified and validated by hard empirical science in over a thousand scientific reports in the last decade. Garlic is uniquely the richest dietary source of healthful sulphur compounds, plus organic selenium as well as being one of the best sources of organic germanium, besides an impressive array of other essential nutrients and active health-promoting phytochemicals. Thus, this study is aimed at assessing the efficacy of garlic in alleviating PAHs lung induced–injury.

On the other hand, *Nigella sativa* (black seed) is a widely used medicinal herb found worldwide. It is native to Southern Europe, North Africa and Southwest Asia and it is cultivated in many countries in the middle-east, south Europe, India, Pakistan, Syria, Turkey and Saudi Arabia. The seeds contain a fatty oil rich in unsaturated fatty acids, mainly linoleic acid (50-60%), oleic acid (20%), eicodadienoic acid (3%) and dihomolinoleic acid (10%). Black seeds and their oil have a long history of folklore usage in Indian and Arabian civilizations, as food and medicine.

Following one of the worst haze episodes affecting Malaysia, in 1997, several studies were conducted to assess the effects of exposure to haze in animal models (rats and chickens). It encompassed both the acute and chronic effects of selected PAHs, with emphasis on determining sensitive and reliable markers of

injuries induced by PAHs apart from the arising pathologies in the exposed lungs with and without garlic (Movassagh et al., 2007; Sanaz et al., 2010) or black seed supplementation (Latif et al., 2009; 2010, 2011a; 2011b; Mazlina et al., 2011) .

The acute exposure studies were performed to determine the presence of apoptosis and proteases activity in the lungs of rats or chickens following treatment with a PAH, either singly or in combination. Rats or chickens not receiving any treatment served as controls while those administered with the tested PAH, instilled intratracheally, were treated with doses of the inhaled PAH based on their concentrations during the peak haze episode of 1997. All the rats or chickens were euthanised at 1, 8 and 24 hours post-instillation (p.i). Apoptosis estimation was made on haematoxylin-eosin stained histopathologic sections, terminal deoxynucleotidyl transferase-mediated dUTP nick-end labeling (TUNEL) analysis and DNA laddering of lung samples. As for protease analyses, total protein content measured by using BSA kit, elastase-like activity and neutrophil elastase activity were performed in the lung lavage collected from the tested animals.

Different phases of apoptosis (Figure 21) were discovered in the pneumocytes and bronchial epithelium of the lung samples of all the PAH-treated rats and chickens. The histopathological (Figure 21) findings showed that there was an increment of apoptotic cells ($p<0.05$) with advancement of time, especially at 8 and 24 hours p.i. This was also confirmed by TUNEL analysis and DNA laddering (Movassagh et al., 2007; Sanaz et al., 2010; Latif et al., 2009; 2010, 2011a; 2011b; Mazlina et al., 2011). Likewise, initial influx of neutrophils followed by macrophages was seen at 8 and 24 hours p.i., respectively (Figure 22).

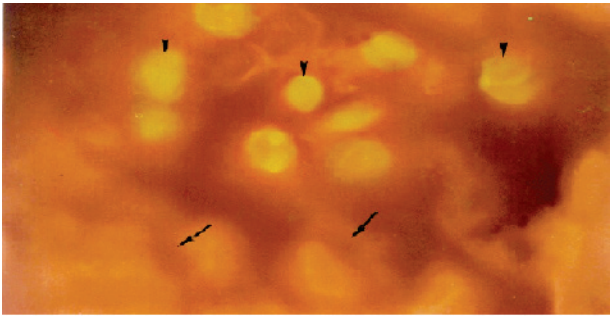

Figure 21 Photomicrograph of a rat lung instilled with a PAH 24 hrs p.i. Note the apoptotic cells (arrowheads) are yellowish green and normal cells are red (arrow). [Fluorescein stain (H&E X500)].

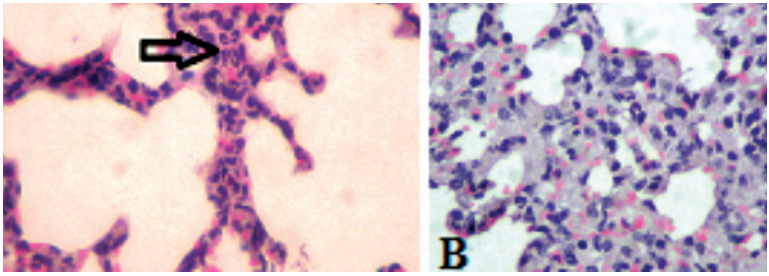

Figure 22 Photomicrograph of the lung of a rat treated with a PAH. (A). Lung tissue examined 8 hrs p.i.. Note the presence of numerous neutrophils (arrows) in the interstitium (H&E, X400). (B). Lung tissue examined 24 hrs p.i. depicts the influx of alveolar macrophages characterized by their eccentrically placed, (arrowhead) ovoid (thin arrow) and kidney-shaped nucleus. (H&E, X400).

The obtained data also showed a time-dependent increase in lung lavage total protein content, elastase-like activity and neutrophil elastase activity during acute exposure (Tables 4).

Table 4 The pulmonary lavage concentration of proteases in rats during acute exposure (OD; Mean±Sd).

Hrs / Grp	Elastase-like			Neutrophil elastase		
	1	**8**	**24**	**1**	**8**	**24**
Cx	0.04 ± 0.01^{aA}	0.04 ± 0.01^{aA}	0.04 ± 0.01^{aA}	0.05 ± 0.01^{aA}	0.05 ± 0.01^{aA}	0.05 ± 0.01^{aA}
F	0.30 ± 0.01^{aB}	0.36 ± 0.01^{bB}	0.47 ± 0.01^{cB}	0.29 ± 0.01^{aB}	0.39 ± 0.01^{bB}	0.44 ± 0.01^{cB}
F+P	0.35 ± 0.01^{aD}	0.58 ± 0.01^{bD}	0.89 ± 0.01^{cD}	0.31 ± 0.01^{aD}	0.50 ± 0.01^{bC}	0.69 ± 0.01^{cD}

^{A,B,C,D,E}Values between column bearing the same superscript/s do not differ at ($P<0.05$),
^{a,b,c,d,e}Values between rows bearing the same superscript/s do not differ at ($P<0.05$),
F = flouranthene, P = pyrene

The chronic exposure studies were conducted as described in the acute study but for a three month period. However, an assessment was also made on the efficacy of garlic or blackseed as an alternative therapeutic agent against PAH. Rats or chickens were assigned into the control, single PAH, combined PAH, garlic or blackseed alone or with either a single or combined PAH groups. The dose of garlic and blackseed were 80mg/kg body weight/rat/day or 20g/kg diet, respectively.

The outcome demonstrated morphological alterations and growth disorders in pneumocytes and bronchial epithelium of rats from all PAH-treated groups (Figure 23, Table 5) along with marked decrease in macrophage phagocytic activity (Figure 24). The PAH-treated groups also showed dreadful effects in proteases activities, levels of IgG, IgA, alveolar macrophages activities and

glutathione-S-transferase in the lung. In contrast, all PAH-treated groups fed with garlic or black seed showed significant improvement in pathological changes, proteases activities, immunology and enzyme activity in the lung (Table 6).

Table 5 The lung lesion scores of rats at necropsy (%; Mean±SD).

Group	Neutrophil	Alveolar macrophage	Emphysema	Hyperplasia	Necrosis
Control	7.7±1.5^{A}	2.7±0.6^{A}	0.0 ±0.0^{A}	0.0±0.0^{A}	0.0±0.0^{A}
G	8.3±0.6^{A}	5.7±1.2^{B}	0.0 ±0.0^{A}	6.0±1.7^{B}	0.00±0.0^{A}
F	29.3±0.6^{B}	33.0±2.7^{C}	23.3±5.8^{B}	25.7± 0.6^{C}	35.0±0.6^{B}
F+G	13.7±1.5^{C}	31.3± 2.1^{C}	0.0±0.0^{A}	18.3±1.2^{D}	8.7±0.6^{C}
P	30.0±0.6^{B}	35.0±1.0^{D}	23.3±2.9^{B}	27.0±1.0^{C}	34.7±0.6^{B}
P+G	11.3±1.5^{C}	34.0±1.7^{D}	0.0 ±0.0^{A}	17.7±0.6^{D}	9.7±0.6^{D}
F+P	32.0±3.0^{B}	34.7±0.6^{D}	40.7±1.2^{C}	27.3±2.1^{C}	40.0±0.6^{E}
F+P+G	12.7±2.3^{C}	34.3±0.6^{D}	0.0±0.0^{A}	20.0±2.7^{D}	10.0±0.6^{D}

^{A,B,C,D,E}Values between column bearing the same superscript/s do not differ at ($P<0.05$), G= garlic, F = flouranthene, P = pyrene

Table 6 The pulmonary lavage concentration of proteases activity in rats during chronic exposure (OD; Mean±SD).

Group	Proteases Activity		
	Total protein	**Elastase-like**	**Neutrophil elastase**
Cx	0.3 ± 0.04^{A}	0.06 ± 0.00^{A}	0.0007 ± 0.00032^{A}
G	0.3 ± 0.03^{A}	0.04 ± 0.00^{A}	0.0012 ± 0.00055^{A}
F	1.7 ± 0.14^{B}	0.3 ± 0.01^{B}	0.0089 ± 0.00400^{B}
F+G	0.4 ± 0.10^{E}	0.05 ± 0.00^{A}	0.0010 ± 0.00045^{E}
P	1.7 ± 0.14^{BC}	0.3 ± 0.01^{BC}	0.0084 ± 0.00374^{C}
P+G	0.4 ± 0.03^{EF}	0.1 ± 0.00^{F}	0.0013 ± 0.00060^{F}
F+P	2.9 ± 0.015^{D}	0.6 ± 0.02^{D}	0.0084 ± 0.00374^{D}
F+P+G	0.4 ± 0.01^{EG}	0.1 ± 0.01^{E}	0.0009 ± 0.00040^{G}

$^{A,B,C,\ D,\ E}$Values between column bearing the same superscript/s do not differ at ($P<0.05$); G= garlic, F = flouranthene, P = pyrene

Concisely, the environmental hazard of PAH, either singly or in combination, to the lungs of rats and chickens as target organs, triggers deleterious changes either by acute or chronic exposure while garlic and black seed have tremendous potential in alleviating the chronic effects of PAH. The efficacy of garlic and black seed in mitigating the toxic effects of PAH is believed to be mediated through the anti-oxidant effects and suppression of PAH converting enzymes (Movassagh et al., 2007; Sanaz et al., 2010; Latif et al., 2009; 2010, 2011a; 2011b; Mazlina et al., 2011).

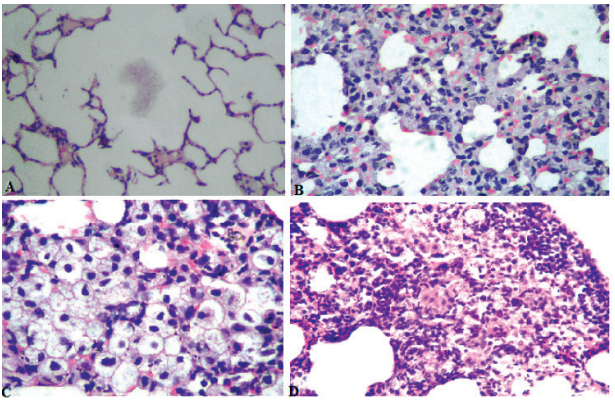

Figure 23 Photomicrograph of lung of rat given a PAH necropsied 90 days post-instillation. A. Note emphysema denoted by marked dilation of alveolar spaces due to rupture of its membrane (H&E, X200). B. There is an increase in the thickness of alveolar wall due to epithelisation (H&E, X400). C. Aggregation of macrophages of which some are foamy (H&E, X600). D. In addition to the thickening of the alveolar septa there is the presence of cells with large eosinophilic cytoplasm resembling an "oat-cell carcinoma". (H&E, X200)

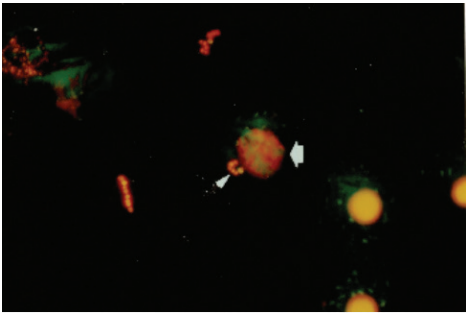

Figure 24 Photomicrograph of lung lavage of a rat instilled with a PAH necropsied at 90 days post-instillation. Note the alveolar macrophages (arrow) with cytoplasmic phagocytosed bacteria (arrowhead) (AO chemiluminescence assay). A marked reduction in the killing activity of alveolar macrophages is seen in lungs exposed to PAH. However, supplementation with either garlic or black seed improved the performance of the macrophages (AO, X500).

MEANDERING THROUGH THE WORLD OF EMERGING AND RE-EMERGING DISEASES: TRANSBOUNDARY INFECTION

The complexity of zoonotic and emerging diseases warrants effective preparedness in handling an outbreak. The factors that contribute to their occurrences include microbial, environmental, host and population dynamics, as well as, ease of worldwide travel and breakdown in control measures. Moreover, the changes in transmission dynamics bring about closer and more frequent contact with zoonotic pathogens, which are involved in 75% of the outbreaks. Thus, with respect to the changes observed, four major areas need to be explored, which are rapid detection, improved surveillance, good early warning systems and appropriate response. Investigation on emergent pandemic infection threats and pathogen discovery are also emphasised as the pro-active phase in predicting and controlling/eradicating an outbreak of a zoonotic and/or emerging disease.

Malaysia, being connected to its south-east Asian neighbours by land and sea, remains vulnerable to the entrance of transboundary emerging or re-emerging diseases (Noordin, 2013; 2015; 2016; Noordin et akl., 2010). The threat does not stop here since aerial transmission of infectious agents can reach any nation through anthropogenic, climatic and vehicular means.

Apart from the Nipah virus encephalitis and avian flu, coenuriasis (Noordin et al., 2010), Q fever, caused by *Coxiella burnetii* is a worldwide zoonosis of public health concern prevalent in parts of New Zealand and Antarctica and now, Malaysia (Norina et al., 2011).

The remarkable phenomenon of caprine Q fever strain, traceable to be infectious in goats bred locally in Malaysia, was very rarely considered when analyzing the DVS policies' directions. Effort

to embark on research in this matter is timely since Malaysia has gone on board to intensify a livestock nucleus project involving the production of high quality imported embryos.

Suprisingly, after 56 years there was a "first" reported outbreak of re-emergence of Q fever in goats in Penang, affecting farmers, veterinarians and members of the Department of Veterinary Services (Norina et al., 2008).

A seroprevalence study (November 2007 to May 2008) on goat flocks in Peninsular Malaysia (Norina et al., 2008) showed that *C. burnetii* infection were widespread in its goat flocks (reactor rate of 3.52-40.53%). Nevertheless, there was also no significant difference between breed reactor rates (relative risk, 1.11; 95% CI, 0.71-1.73). This suggests that *C. burnetii* infections may have been in Malaysia prior to the importation of the Boer goats. It is believed that underdeveloped policies of importation, quarantine stations and screening of tropical diseases could have contributed to such outbreaks in humans and animals (Norina et al., 2008).
Generally, Q fever infection occurs through inhalation of contaminated aerosols leading to subclinical disease that has been associated with late abortions, stillbirth, delivery of weak offsprings and also infertility.

Rapid diagnosis of the aetiological agent of caprine abortion in Malaysia is of great importance in terms of control and prevention. Routine diagnosis of Q fever in Malaysia is usually based on the detection of specific antibodies in the adult population by ELISA tests which at times may give false negative results (Norina et al., 2011). In the act of assisting the Department of Veterinary Services in their control and prevention of diseases programme, a study was done to generate a set of databases and to map out areas of Q fever infection in Malaysia.

A total of 2266 sera taken from 108 goat farms for surveillance involving six states revealed that *C. burnetii* is widespread irrespective of breeds in Peninsular Malaysia (Figure 25; Norina et al., 2011).

Additionally, the risk analysis is in agreement that the female is prone to a higher risk of getting Q fever (95%CI, 1.064–1.206). It believed that sex hormones play a role in pathogenesis of Q fever infection. Age also appears to be a risk factor for Q fever where goats of less than 2 years of age bear a much higher risk compared to older animals (1.13 95%CI, 0.677–1.89). Haemogram changes of a high haemoglobin concentration, leukocytosis and thrombocytosis are indicative of Q fever infection in goats.

Figure 25 Map indicating the prevalence of Q fever in Peninsular Malaysia being highest in the Klang Valley and lowest in Selangor.

Owing to shedding of *C. burnetii* in amniotic fluids, placenta, faeces, urine and milk, a total of 150 carcasses from 5 infected goat farms with a history of abortion storm in the northern zone were necropsied. Gross findings revealed necrotic placentitis with diffused white foci creamy exudates at the edges of the cotyledons and in the intercotyledonary areas (Figure 26). The organism can be demonstrated with the use of Giemsa and Machievello stains which can be conducted at any regional laboratory (Figure 26).

Since the organism is intracellular in nature and not all regional laboratories are equipped with tissue culture or IHC facilities, inoculating infected tissues into embryonated eggs is a diagnostic option. The yolk sac of the SPF embryonated chicken egg at 10-day post-inoculation can then be stained with Machiavello and Gimenez stains (Figure 27). The results can be easily interpreted as the positive results stand-out clearly from the surrounding tissue. Histopathologically, necrotic placentitis, interstitial pneumonia, hepatitis and nephritis were seen in a majority of cases (Figure 28). Acute cases yielded lesions conforming to doughnut granuloma while those of the chronic form exhibited chronic inflammation. Out of the total suspected cases, 152 (77.2%) were confirmed as being positive for Q-fever, based on immunohistochemistry (IHC) analysis. Our study has demonstrated pertinent lesions of acute and chronic forms of Q-fever which is beneficial to laboratories without IHC facilities. Furthermore, the study has also enabled the correct submission of samples from the field as there is a good correlation between the H&E and IHC stained placenta, lung and liver (Figure 29).

Thirty placentas and umbilical cords of two foetuses stained with the Giemsa and Machiavello (MAC) staining revealed hazy bluish structures within the cytoplasm of trophoblasts that contained small, red coccobacilli organisms.

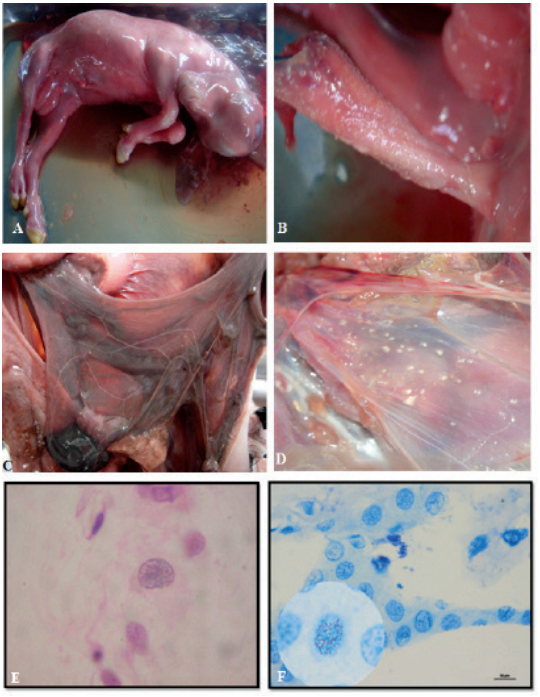

Figure 26 Photographs and photomicrographs of tissues obtained post mortem from affected does. A. Foetus in affected does remain without gross lesions as opposed to that in cases of brucellosis. B. Diffused white foci along the umbilical cord is a prominent feature of caprine Q fever. C & D. Another common feature seen in cases of caprine Q fever is whitish necrotic foci on the cotyledon and caruncle of the placentome, respectively. E & F. Photomicrographs demonstrating cyst-like trophoblast contain bluish cocobacilli organisms (arrows) on direct impression smear of the placenta (Giemsa, X1000) and red coccobacilli organisms with bluish background on direct impression smear of the foetus liver (Machievello, X1000), respectively.

The placentas were inoculated into 7-day-old SPF embryonated chicken eggs which led to a cloudy chorion with small white foci attached to the chorionic membrane, collapse of blood vessels,

diffused haemorrhage and corneal opacity of the embryo. Harvested yolk sac stained with Machiavello and Gimenez stains showed the presence of numerous red coccobacilli *C. burnetii* attached to the yolk sac (Figure 27). This finding was later confirmed by immunohistochemistry (IHC) in all six tissues (100%) where positive brownish granules appeared against a green background.

The PCR is a much safer and useful method for detection and diagnosis of *C. burnetii* by targeting transposon-like repetitive regions but is off-limits to most regional laboratories. At present, PCR techniques are useful as diagnostic tools for detection of *C. burnetii* in caprine aborted foetuses and in caprine genital swabs. Four, three and four frozen placental, fresh placental and fresh vaginal swabs, respectively, from does with a history of abortion were positive on PCR for *Coxiella burnetii*.

The methods developed in this study provide a basis for confirming a case of Q fever at the regional laboratory level. Alternatively, more comprehensive understanding and awareness on the evolution of Q fever will hopefully lead to the development of improved epidemiological and diagnostic tools contributing to the existing disease control programmes in Malaysia in the future.

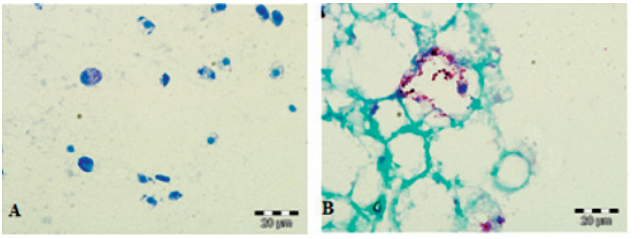

Figure 27 Photomicrograph demonstrating, at a dilution of 10^{-9} on day 10 post-inoculation, pink coccobacilli of *Coxiella burnetii* (arrow) on direct impression smear on the yolk sac (X1000; Machiavello stain);(B) while Gimenez stain revealed pink coccobacilli of *Coxiella burnetii* with green background (X1000; Gimenez stain)

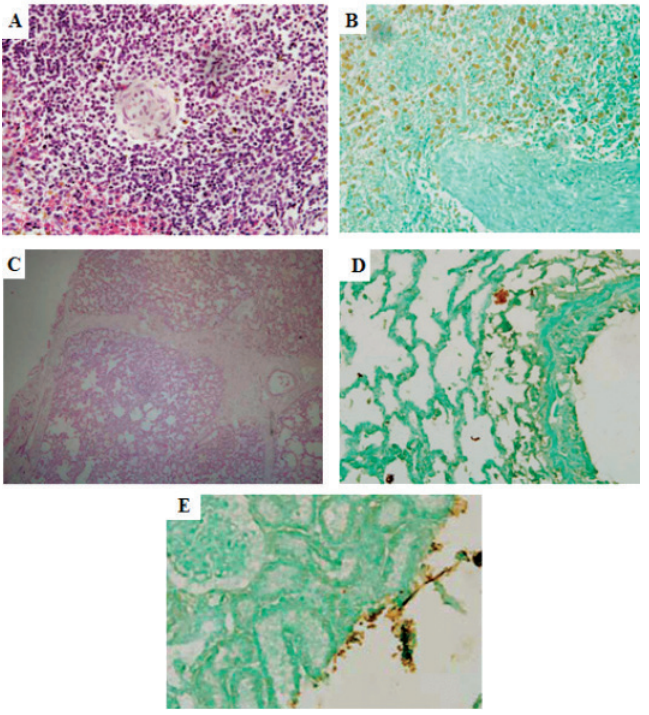

Figure 28 Photomicrographs of liver, lung and kidney from infected does. (A). Liver shows the typical feature of what is known as a doughnut granuloma (H&E, X 200). (B). The IHC of the infected liver demonstrates the diffusely distributed positive areas within the liver parenchyma. (C). The lung with a rather bizarre feature of bacterial infection conforming to intersititial pneumonia (H&E, X200). (D). The IHC of the lung shows the presence of positive areas within the alveoli. (E). Immunopositive reaction in the kidneys depict predilection sites of tubules. Both distributions of immunopositive areas in the lung (D) and kidneys (E) explain the route of excretion of the bacteria into the environment.

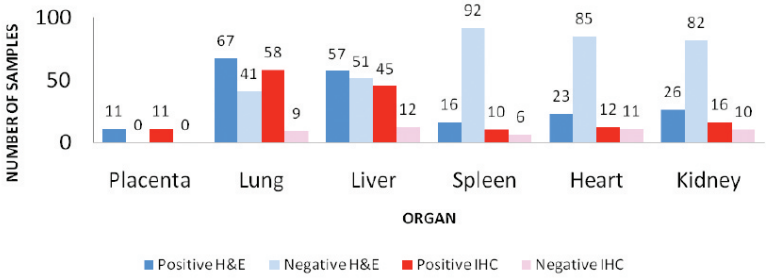

Figure 29 Histogram comparing the specificity and sensitivity of the IHC used against that of H&E stained lesions. Tissues to be collected in cases of Q fever are from the placenta, lung and liver.

MEANDERING THROUGH THE WORLD OF NUTRACEUTICALS: LOCAL HERBS WITH PHARMACEUTICAL POTENTIAL

The booming herbal industry has been identified as a source of national economic growth of the Entry Point Projects under the Agricultural National Key Economic Areas in the Economic Transformation Programme. The herbal industry is estimated to reach a market value of USD115 billion by the year 2020, with a 9.1% compound annual growth rate (CAGR), in the Asia-Pacific region. Malaysia expects its herbal industry to expand by 15% a year, from RM7 billion in 2010 to around RM29 billion by 2020 (Ahmad et al., 2015). This flourishing growth rate prediction for this industry is due to a changing mind set and awareness on alternative health care and disease prevention (Noordin, 2008; Ahmad and Othman, 2015).

Owing to the high incidence of cholesterol-induced cardiovascular diseases, particularly atherosclerosis, a study was designed to investigate the preventive and therapeutic efficacies of dietary zerumbone (ZER) supplementation on the formation and

development of atherosclerosis in rabbits fed with a high cholesterol diet. *Zingiber zerumbet* (Linnaeus) Smith,(ZER) belonging to the family *Zingiberaceae*, an edible ginger originating in South-East Asia (Ruslay et al., 2007), is an effective antioxidant in suppressing the generation of free radicals (Murakami et al., 2002) where this is especially important because oxidative stress plays a key role in the process of atherogenesis (Schulze et al., 2006). Furthermore, ZER attenuates free radical generation by chronic inflammatory cells (macrophages and lymphocytes) as an antioxidant, cancer-preventive agent with a pivotal role in fatty streaks formation, plaque accumulation and in early lesion development (Song et al., 2001; Galkina & Ley, 2009).

New Zealand White rabbbits used as models were divided randomly into two experimental set-ups executed eight weeks apart. The first set-up was designed to investigate the prophylactic efficacy of ZER in preventing early developed atheromatous lesions while the second was to assess the therapeutic efficacy of ZER. The latter set-up was to assess the efficacy of ZER in reducing atherosclerotic lesion progression and establishment. Assessment of both efficacies was based on clinical outcome, selected biochemical parameters and pathology (gross, microscopic including histochemistry, immunohistochemistry and ultrastructure).

Generally, tissues of rabbits fed a high cholesterol diet were pale resulting from the excess deposition of cholesterol into the tissues (Figure 30). Almost all the rabbits fed the high cholesterol diet developed myocardial infarction at the apex of the heart (Figure 31).

Sudanophilia, histopathological, and ultrastructural changes showed pronounced reduction in the plaque size in ZER-medicated aortas (Figures 32-36). On the other hand, dietary supplementation of ZER for almost 10 weeks as a prophylactic measure indicated substantial decrease in lipid profile values, and similarly, plaque size,

in comparison with that in the high-cholesterol non-supplemented rabbits (Figures 32). Furthermore, the results of oxidative stress and antioxidant biomarker evaluation indicated that ZER is a potent antioxidant in suppressing the generation of free radicals, in terms of atherosclerosis prevention and treatment. Zerumbone significantly reduced the value of malondialdehyde and augmented the value of superoxide dismutase. In conclusion, the data indicated that dietary supplementation of ZER at doses of 8, 16 and 20 mg/kg alone as a prophylactic measure, and as a supplementary treatment with simvastatin, significantly reduced early plague formation, development, and establishment, via significant reduction in the serum lipid profile, together with suppression of oxidative damage, and therefore alleviated atherosclerosis lesions.

Many other herbs with potential pharmaceutical properties have been investigated, in most cases initially based on their anti-oxidant properties (Noordin, 2008). Due to spatial limitations, worth mentioning here are our other indirect research pertaining to nutraceuticals which involves the use of pathology, which include those related to ageing (Imilia et al., 2002), anti-diabetic (Matanjun et al., 2008; 2009; Hasliza et al., 2011; Mohamed et al., 2011; Shukri et al., 2010; 2011), anti-hypertensive (Juliana et al., 2007; Jaffri et al., 2011a; 2011b; 2011c), anti-asthmatic (Abu-Bakar et al., 2015), anti-inflammatory (Abu Bakar et al., 2015; Matanjun et al., 2008; 2009; 2011; Manaf et al., 2016), anti-hypercholesterolaemia (Tee et al., 2002; Irene et al., 2003; Mohamed et al., 2003; Choong et al., 2007; Matanjun et al., 2011; Khairullah et al., 2014; Roslina Tan et al., 2011) anti-osteoporosis (Baksh et al., 2013) and anti-cancer (Choong et al., 2007; 2008;; Matanjun et al., 2008; 2009; 2011; Namvar et al., 2009; 2012; Tong et al., 2008; 2009; Keong et al., 2010; Dina et al., 2011; Huthefya et al., 2011; Khairullah et al., 2014; Lim et al., 2016a; 2016b; Nurul et al., 2016).

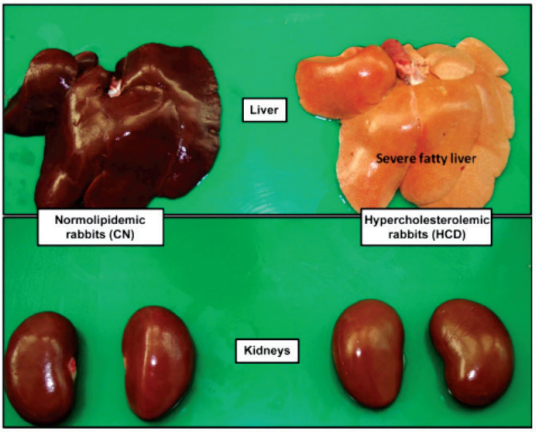

Figure 30 Photograph of the liver and kidneys of rabbits at the end of the trial. Both organs appear pale in the rats receiving a high cholesterol diet (HCD).

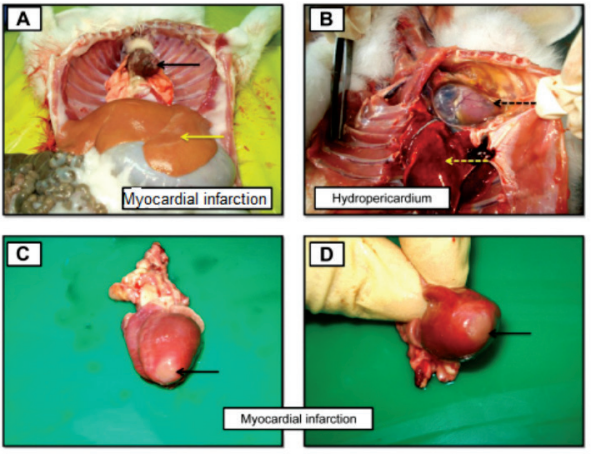

Figure 31 Photograph of the liver and heart of rabbits fed a high cholesterol diet at the end of the experiment. Note that most of the organs are pale where pale areas at the apex of the heart shows the development of myocardial infarction, similar to ischaemic heart disease (IHD)-like lesions.

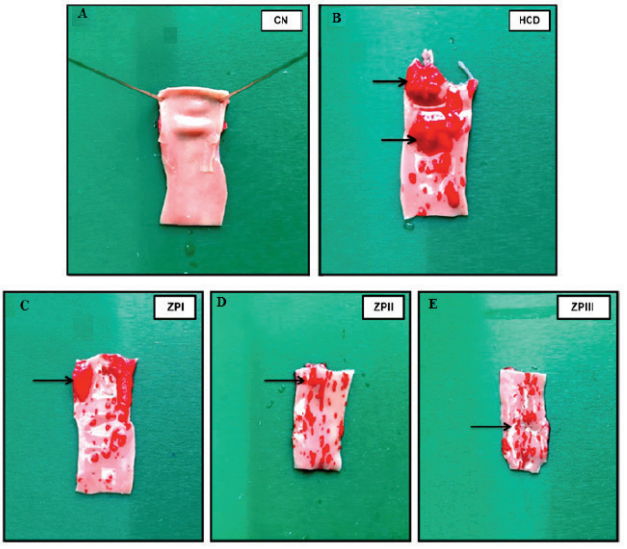

Figure 32 Photograph of the Sudan IV–stained thoracic aorta of rabbits from the control (CN), high cholesterol diet (HCD) and graded doses of zerumbone (ZPI, ZPII and ZPIII) groups at post mortem. Note marked Sudan IV staining reaction in the HCD group and the lesser intense staining with increasing dose of zerumbone (D to E).

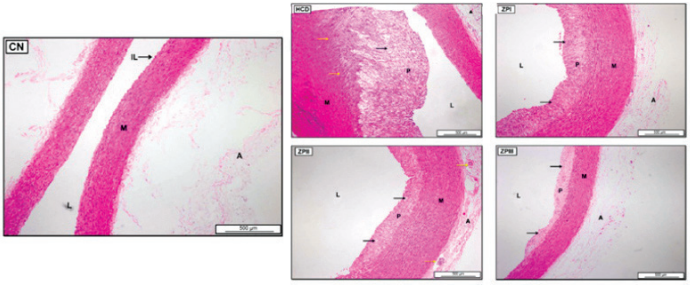

Figure 33 Photomicrograph of thoracic aorta of the rabbits from the control (CN), high cholesterol diet (HCD) and graded doses of zerumbone (ZPI, ZPII and ZPIII) groups at post mortem. The establishment of artherosclerosis is effectively diminished by zerumbone, especially at higher doses. (H&E, X200)

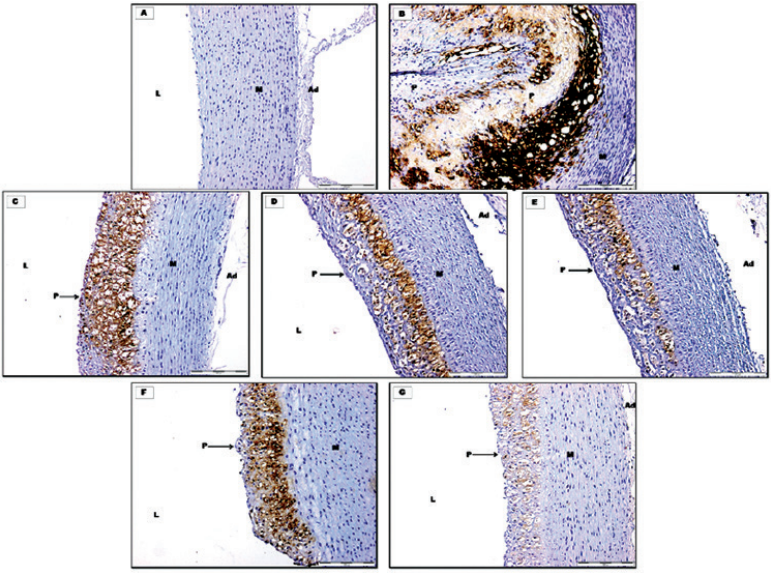

Figure 34 Photomicrograph of thoracic aortas of rabbits immunohistochemically stained with RAM-11 antibody from the control (CN), high cholesterol diet (HCD) and graded doses of zerumbone (ZPI, ZPII and ZPIII) groups at post mortem. A significant reduction tunica media RAM11 biomarker staining is displayed in rabbits receiving zerumbone. Obviously, there is no reaction in the muscularis layer (M), P= intimal plaque; L: Lumen, Ad: Adventitia. (100X).

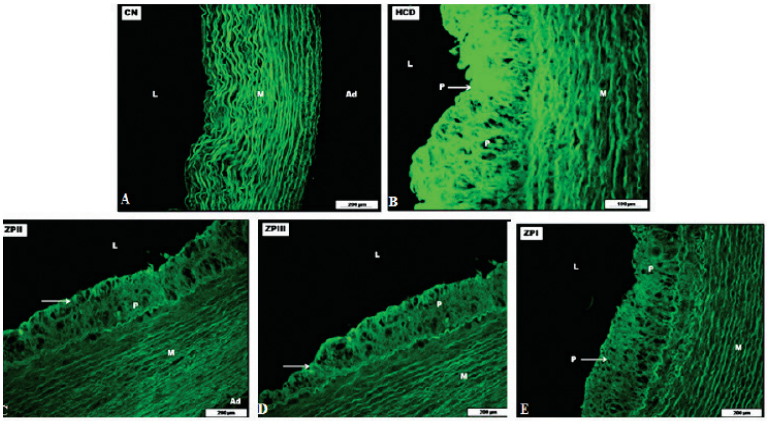

Figure 35 Photomicrograph of thoracic aortas from HCD, ZPI, ZPII and ZPIII represent immunoflourescent staining with RAM-11 antibody. Aortas in ZPI, II and III groups demonstrate significant reduction in the macrophage-derived foam cells within the tunica intima compared to the HCD group, indicated by low intensity of greenish-fluorochrome immunopositive RAM-11 cells in the intimal plaque. L: Lumen; P: Plaque; M: Media; Ad: Adventitia. Scale bars: 200 µm

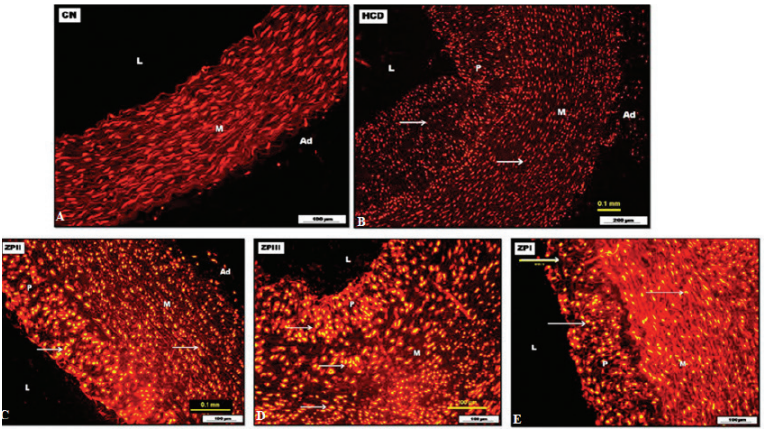

Figure 36 Photomicrograph of thoracic aorta of rabbits from the Control (A), HCD (B), ZPI (C), ZPII (D) and ZPIII (E) groups at post mortem stained for *in vivo* antiproliferative effect of zerumbone (TUNEL assay). Aorta in ZPI, II and III groups show significant augmentation in the number of apoptotic cells in both intimal plaque (P) and muscularis (M). L: Lumen; M: Muscularis layer; Ad: Adventitia. Scale bars: 100µm

CONCLUDING REMARKS

It appears that pathology as a discipline in medicine can form an integral part of research excellence. Commencing from verifying the development of a functional model to assessment of progression of the model towards its targeted objective and the assessment of the efficacy of a new therapy can be achieved via pathology. This short review has at its best shown how pathology fits into most other branches of medicinal research in exploring the intrapolated postulations. However, this is just one aspect of the usage of pathology in research and its other major action is always in diagnosis. Nevertheless, the methods of confirming a diagnosis are derived from earlier observations either from the field or research experiences, utilising pathology as one of the key instruments

to measure tissue changes. Although the terminologies used in describing abnormality remains unchanged but the wandering path of pathology across research and diagnostic disciplines still remains validly warranted.

REFERENCES

Abas, M.O. and Sharif, H. (1988). Hepatotoxicity in indigenous sheep of Malaysia stall-fed with different forms of *Brachiaria decumbens. Pertanika Journal of Tropical Agricultural Science, 11*, 57-61.

Abba, Y., Hassim, H.A., Hamzah, H., & Noordin, M.M. (2014). Anti-oxidant effects of ascorbic acid and resveratrol treatments on Vero cells infected with boid inclusion body disease virus. Proceedings of the 6th Malaysian Association of Veterinary Pathology Scientific Conference, 21st -24th August, 2014, Best Western Marina Island Resort, Pangkor, Perak

Abba, Y., Hassim, H.A., Hamzah, H. and Noordin, M.M. (2015a). Antiviral activity of resveratrol against human and animal viruses. *Advances in Virology,* art. no. 184241.

Abba, Y., H.A., Hassim, H.A., Hamzah, and M.M., Noordin (2015b). Antioxidant vitamins, oxidant injuries and diseases. *Pertanika Journal of Scholarly Research Reviews, 1*(1), 58-66

Abba, Y., Hassim, H.A., Hamzah, H., & Noordin, M.M. (2015c): Hemato-biochemical and histopathological responses of mice to resveratrol treatment following infection with boid inclusion body disease virus (BIBDV). Proceedings of the 7th Malaysian Association of Veterinary Pathology Scientific Conference, 20th -23rd August, 2015, Makhota Hotel, Melaka.

Abba, Y., Hassim, H.A., Hamzah, H., Ibrahim, O.E., Ilyasu, Y., Bande, F., Mohd Lila, M.A. and Noordin, M.M. (2016). *In vitro* isolation and molecular identification of reptarenavirus in Malaysia. *Virus Genes,* 1-11. (in press).

Abdulazeez, I. O. (2011). *Use of Molecular Markers, Body Temperature and Radiography in Estimating Post Mortem Interval in Dogs in the Tropics.* (Doctor of Philosophy), Universiti Putra Malaysia, Malaysia.

Abdulazeez, I.O., and M.M., Noordin, (2010). Algor mortis pattern in dogs, a guide to estimation of time of death. *Pertanika Journal of Tropical Agricultural Science, 33*, 105-111.

Abdulazeez, I. O., & Noordin, M. M. (2016). Ribonucleic acid concentration in postmortem interval (PMI) estimation in dogs in the tropics. *International Medicine Journal,* (in press.)

Abdullah, A.S., Noordin, M.M. and M.A., Rajion, 1989. Neurological disorders in sheep during Signal grass (Brachiaria decumbens) toxicity, *Veterinary and Human Toxicology*, *31*,128-129.

Abdullah, A.S., Noordin, M.M. and Rajion. M.A. (1988). Signal grass (Brachiaria decumbens) toxicity in sheep: Changes in motility and pH of reticulo-rumen. *Veterinary and. Human Toxicology*, *30,* 256-258.

Abdullah, A.S.,Lajis, N.H., Bremner, J.B., Davies, N.W., Mustapha, W. and Rajion, M.A. (1992). Hepatotoxic constituents in the rumen of Brachiaria decumbens intoxicated sheep. *Veterinary and Human Toxicology*, 34,154-155.

Abu Bakar, N., Anyanji, V.U., Mustapha, N.M., Lim, S-L. and S., Mohamed (2015). Seaweed (Eucheuma cottonii) reduced inflammation, mucin synthesis, eosinophil infiltration and MMP-9 expressions in asthma-induced rats compared to Loratadine. *Journal of Functional Foods*, *19*, 710-722.

Ahmad, S. and Othman, N. (2015). Malaysia herbal industry: profile of SMES. *Journal of Scientific Research and Development,* 2, 74-78.

Ahmad, F., Zaidi, M.A.S., Sulaiman, Abdul Majid, F.A. (2015). Issues and Challenges in the Development of the Herbal Industry in Malaysia. *Prosiding PERKEM,* **10**: 227–238, Persidangan Kebangsaan Ekonomi Malaysia ke-10 (PERKEM 10), Kekayaan Terangkum Teras Pembangunan Lestari,Melaka Bandaraya Bersejarah, 18 – 20 September 2015.

Anonymous (1998). EPA (Environmental Protection Agency). Air Quality Criteria for Particulate Matter. *http://www.epa.gov/ncea/pdfs/0617v1fm.pdf*. Accessed on 15 June 2016.

Assumaidaee, A.A., Zamri-Saad, M., Jasni, S. and Noordin, M.M. (2010). The role of oxidative stress in Brachiaria decumbens toxicity in sheep, *Pertanika Journal of Tropical Agricultural Science*, *33*, 151-157.

Bakhsh, A., Mustapha, N.M. and Mohamed, S. (2013). Catechin-rich oil palm leaf extract enhances bone calcium content of estrogen-deficient rats. *Nutrition*, *29*, 667-672.

Benner, B.A., Bryner, N.P., Wise, S.A., Mulholland, G.W., Lao, R.C., and Fingaa, M.F. (1990). Occupational exposure to polycyclic aromatic hydrocarbons and lung cancer. *Environmental Science and Technology*, *24*,1418 1427.

Bree, S. H. (1994). Common Alternative Therapies: Garlic. Men Health Crisis: *Treatment Issues*, *7*,11-12.

Briton, N.W. and Paltridge, T.B. (1940). Preliminary note on photosensitisation on sheep grazing on *Brachiaria brizantha. Royal Society of Queensland Proceedings, 52*,121-122.

Chang, L. W., & Jacobson, E. R. (2010). Inclusion body disease, a worldwide infectious disease of boid snakes: a review. *Journal of Exotic Pet Medicine*, *19*, 216-225.

Choong, Y.K., Mustapha, N.M., Mohamed, S., Umar, N.A.B. and Tong, C.C. (2007). Effect of ling zhi or reishi mushroom Ganoderma lucidum (W. Curt.: Fr.) P. Karst. mycelium on benzo[a]prene-induced early alterations of the respiratory epithelium in the hypercholesterolaemic rats. *International Journal of Medicinal Mushrooms, 9*,139-150.

Choong, Y.K., Noordin, M.M., Mohamed, S., Ali, A.M., Umar, N.A.B. and Tong, C.C. (2008). The nature of apoptosis of human breast cancer cells induced by three species of genus Ganoderma P. Karst. (Aphyllophoromycetideae) crude extracts. *International Journal of Medicinal Mushrooms*, *10*, 115-125.

Dina, P.F., Hazilawati, H., Rosly, S.M., Shanmugavelu, S. and M.M., Noordin, (2011). Expression of circulating CD146 associated with endovascular dysfunction in adenine-induced chronic renal damage in rats using an evagreen real-time RT-PCR assay. *Pertanika Journal of Tropical Agricultural Science, 34*, 381-391.

Finlayson-Pitts, B.J. and Pitts, J.N. (1986). Atmospheric Chemistry: Fundamentals and experimental techniques. John Wiley, New York, USA.

Galkina E. and Ley, K. (2009). Immune and inflammatory mechanisms of atherosclerosis. *Annual Review of Immunology*, ***27***, 165–197.

Hamzah, H., Sayuti, N.S.A., Iffendi, S.N.N.A.M,, Salih, H.S., Shaary, M.R., Zain, W.S.W.M., Esa, N.M., Sithambaram, S., Noordin, M.M. and Sabri, J. (2016). Low level of cyclooxygenase-2 transcript in the spleen of lymphoma rats supplemented with garlic powder. *Asian Journal of Pharmaceutical and Clinical Research*, *9*, 1-6.

Hasliza, A.H., Noordin, M.M. and Goh, Y.M. (2011). Effects of exercise and dietary polyunsaturated fatty acid on blood lipid profiles of streptozotocin-induced diabetes in rats. *Pertanika Journal of Tropical Agricultural Science*, *34*, 151-155.

Hazilawati, H., Farah Dina, P., Rosly, S.M., Shanmugavelu, S. and Noordin, M.M. (2010). Phyllanthus niruri reduces renal azotaemia in rats induced with chronic renal failure. *The Medical Journal of Malaysia*, *65*, 132-134.

Heil, A. (1998). Air pollution caused by large-scale forest fires in Indonesia 1997. Paper presented at South-East Asian Land/Forest Fires: Science and Policy Workshop, Centre for Remote Imaging, Sensing and Processing (CRISP), 30 April-2 May 1998. Singapore.

Hemn, H.O., Noordin, M.M., Rahman, H.S., Hazilawati, H., Zuki, A.B.Z and Chartrand, M.S. (2015). Antihypercholesterolemic and antioxidant efficacies of zerumbone on the formation, development, and establishment of atherosclerosis in cholesterol-fed rabbits. *Drug Design, Development and Therapy*, *9,* 4173-4208.

Henssge, C. (1988). Death time estimation in case work-I. The rectal temperature time of death normogram. *Forensic Science Inernational,* 38, 209-236

Hutheyfa A.H., Hazilawati, H., Rosly, S.M., Jasni, S., Noordin, M.M. and Sithambaram, S. (2011). Histopathological features of peripheral T-cell lymphoma in Sprague Dawley rats induced with N-methyl-N-nitrosourea. *Pertanika Journal of Tropical Agricultural Science, 34*, 351-361.

Ibrahim E.O. (2013). Comparative in vitro and in vivo Pathogenesis of Experimentally Induced Inclusion Body Disease of Boids. *PhD Thesis, Universiti Putra Malaysia.* 1-162

Ibrahim, A.O., Zuki, A.B.M. and Noordin, M.M. (2012). Applicability of Virtopsy in Veterinary Practice: A Short Review. Pertanika Journal of Tropical Agricultural Science, *35*, 1-8.

Ilyasu, Y. (2016): Isolation and Identification of Cellular Stress Proteins associated with Boid Inclusion Body Disease. *MVSc Thesis, Universiti Putra Malaysia.* 1-70

Ilyasu, Y., Abba, Y., Bande, F., Zunita, Z., Mohd-Azmi, M.L. and Noordin, M.M., (2015a): Identification of cellular stress proteins in python bivittatus naturally infected with boid inclusion body disease virus. *IOSR Journal of Agriculture and Veterinary Science*, *8,* 20-25.

Ilyasu, Y., Abba, Y., Zunita, Z., Mohd-Azmi, M.L. and Noordin, M.M. (2015b). Diagnosis of boid inclusion body disease: Challenges and Future Prospects. IOSR *Journal of Agriculture and Veterinary Science*, *8*, 77-82.

Imilia, I., M.M., Noordin, and S., Mohamed, 2002. Anti ageing efficacy of Phaeomeria speciosa (bunga kantan) and Piper betel (sireh). Proceedings of the Seminar of the Malaysian Natural Products Society, 18, Kota Kinabalu, Sabah (Malaysia), 21-24 Oct 2002.

Irine, R., Noordin, M.M., Radzali, M., Azizah, H., Hapizah, N., Mahinda, Y.A, Suhaila, M. (2003). Antioxidant and hypocholesterolemic effects of Elaeis guineensis frond extract on hypercholesterolemic rabbits. *ASEAN Food Journal*, *12*,137-148.

Jaffri J.M., Mohamed, S., Ahmad, I.N. and Noordin, M.M. (2011a). Effects of catechin-rich oil palm leaf extract on normal and hypertensive rats' kidney and liver. *Food Chemistry*, *28*, 433-441.

Jaffri J.M., Mohamed, S., Rohimi, N. and Ahmad, I.N., Noordin, M.M. and Manap, Y.A. (2011b).Antihypertensive and cardiovascular effects of catechin-rich oil palm (Elaeis guineensis) leaf extract in nitric oxide–deficient rats. *Journal of Medicinal Food*, *14*, 775-783.

Juliana M.J., Suhaila, M., Tariq, A.R., Noordin, M.M. and Yazid, Y.M. (2007). Oil palm frond methanolic extract attenuates blood pressure increases in nitric oxide deficient rats. *Malaysian Journal of Medical Sciences*, *14* **(**Suppl)**:**161

Kaliszan, M. (2012). First practical applications of eye temperature measurements for estimation of the time of death in casework. Report of three cases. *Forensic Sci Int, 219:* e13-15. doi:10.1016/j.forsciint.2011.11.027

Kayser, M. and Knijff, P. D. (2011). Improving human forensics through advances in genetics, genomics and molecular biology. *Nature Reviews Genetics, 12*,179-192.

Keong, C.Y., Chin, T.C., Umar, N.A., Mustapha, N.M. and Mohamad, S. (2010). The effects of a powder of the fruiting body of commercial Lingzhi or Reishi medicinal mushroom Ganoderma lucidum (W.Curt.:Fr.) P.Karts., on hypercholesterolemic rat skin, applied with a topical application of benzo(a)pyrene, *International Journal of Medicinal Mushrooms*, *12*, 367-378.

Khairullah Z., H., Hazilawati, and S.M., Rosly, 2014. Evaluation of The Acute And Subacute Dermal Toxicity Of The Ethanolic Fruit Extract Of Morinda Citrifolia in Male And Female Rats. Veterinary Research,pages :395

Kim C.S. and Kang T.C. (1997). Comparative measurement of lung deposition of inhaled fine particles in normal subjects and patients with obstructive airway disease. *American Journal Respiratory Critical Care and Medicine, 155*, 899-905.

Lajis, N.H., Abdullah, A.S.H., Salim, S.J.S., Bremmer, J.B. and Khan, M.N. (1993). Epi-sarsasapogenin and epi-smilagenin: two sapogenins isolated from the rumen content of sheep intoxicated by Brachiaria decumbens. *Steroids*, *58*, 387-389.

Latif I.K., Karim, A.J., Zuki, A.B.Z., Zamri-Saad, M., Niu, J.P. and Noordin, M.M. (2009). Respiratory macrophage activity and pulmonary morphology following exposure to benzo(a)pyrene in broilers. *Online Journal of Veterinary Research*, *13*, 128-135.

Latif I.K., Karim, A.J., Zuki, A.B.Z., Zamri-Saad, M., Niu, J.P. and Noordin, M.M. (2011a). Nigella sativa meal alleviates injury against Benzo[a]Pyrene exposures in broilers. *Pertanika Journal of Tropical Agricultural Science*, *34*, 157-162.

Latif I.K., Karim, A.J., Zuki, A.B.Z., Zamri-Saad, M., Niu, J.P. and Noordin, M.M. (2011b). Efficacy of Nigella sativa in alleviating benzo[a]pyrene-induced immunotoxicity in broilers. *Histology and Histopathology*, *26*, 699-710.

Latif I.K., Karim, A.J., Zuki, A.B.Z., Zamri-Saad, M., Niu, J.P. and Noordin, M.M. (2010). Pulmonary modulation of benzo[a]pyrene-induced hemato-and hepatotoxicity in broilers. *Poultry Science*, *89*, 1379-1388.

Lim, S.-L., Mustapha, N.M., Goh, Y-M., Bakar, N.A.A. and Mohamed, S. (2016). Metastasized lung cancer suppression by Morinda citrifolia (Noni) leaf compared to Erlotinib via anti-inflammatory, endogenous antioxidant responses and apoptotic gene activation. *Molecular and Cellular Biochemistry*, *416*, 85-97.

Lim, S.-L., Goh, Y.-M., Noordin, M.M., Rahman, H.S., Othman, H.M., Abu Bakar, N.A. and Mohamed, S. (2016). Morinda citrifolia edible leaf extract enhanced immune response against lung cancer. *Food and Function*, *7*:741-751.

Manaf, S.R., Daud, H.M., Alimon, A.R., Mustapha, N.M., Hamdan, R.H., Muniandy, K.G., Mohamed, N.F.A., Razak, R. and Hamid, N.H. (2016). The effects of Vitex trifolia, Strobilanthes crispus and Aloe vera herbal-mixed dietary supplementation on growth performance and disease resistance in red hybrid Tilapia (Oreochromis sp.). *Journal of Aquaculture Research & Development*, *7*:425.

Matanjun, P., Mohamed, S., Muhammad, K. and Mustapha, N.M. (2010). Comparison of cardiovascular protective effects of tropical seaweeds, Kappaphycus alvarezii, Caulerpa lentillifera, and Sargassum polycystum, on high-cholesterol/high-fat diet in rats. *Journal of Medicinal Food*, *13*:792-800.

Matanjun, P., Mohamed, S., Mustapha, N.M. and Muhammad, K. (2009). Nutrient content of tropical edible seaweeds, Eucheuma cottonii, Caulerpa lentillifera and Sargassum polycystum. *Journal of Applied Phycology*, *21*:75-80.

Matanjun, P., Mohamed, S., Mustapha, N.M., Muhammad, K. and Ming, C.H. (2008). Antioxidant activities and phenolics content of eight species of seaweeds from north Borneo. *Journal of Applied Phycology*, *20*:367-373.

Mazlina, M., Karim, A.J., Zamri-Saad, M.and Noordin, M.M. (2011). Pulmonary lesions associated with intratracheal benzo(a)pyrene instillation in Sprague Dawley rats. *Pertanika Journal of Tropical Agricultural Science*, 34, 367-372.

Mohamed, S., Noordin, M.M., Baharuddin, I.R., Abdullah, R. and Hamsan, K. (2003). The effects of Cymbopogon citratus (Serai) on the heart, liver and kidney of normal and hypercholesterolaemic rats. *Journal of Tropical Medicinal Plants*, *3*, 1.

Mohamed, S., Matanjun, P., Hashim, S.N., Rahman, H.A. and Mustapha, N.M. (2011). Edible seaweeds: A functional food with organ protective and other therapeutic applications, Seaweed: Ecology, Nutrient Composition and Medicinal Uses. pp 67-98.

Movassagh, S., Noordin, M.M., Sheikh-Omar, A.R., Hassan, M.D. (2007). Effect of Allium sativum (garlic) on immunoglobulin levels in rats. *Journal of Tropical Medicinal Plants*, *8*:1-4.

Movasaggh, S., M., Noordin, M.M., Sheikh-Omar, A.R. & Hassan, M.D. (2006). The efficacy of garlic (*Allium sativum*) on IgA and IgG levels in rats intra-tracheally exposed to benz[a]anthracene. *National Conference on Food Science and Nutrition*, 13-15 December 2006, Kota Kinabalu, Sabah, Malaysia pp 307-313

Murakami, A., Takahashi, D., Kinoshita, T., Koshimizu K., Kim, H.W., Yoshihiro, A., Nakamura, Y., Jiwajinda, S., Terao, J., Ohigashi, H. (2002). Zerumbone, a Southeast Asian ginger sesquiterpene, markedly suppresses free radical generation, proinflammatory protein production, and cancer cell proliferation accompanied by apoptosis: the α, β-unsaturated carbonyl group is a prerequisite. *Carcinogenesis*, *23*, 795–802

Namvar, F., Mohamed, S., Behravan, J., Mustapha, M.N., Alitheen, N.B.M. and Othman, F. (2009). Estrogenic activity of Elaeis guineensis leaf. *Pharmacologyonline*, *2*, 818-826.

Namvar, F., Mohamed, S., Fard, S.G., Behravan, J., Mustapha, N.M., Alitheen, N.B.M. and Othman, F. (2012). Polyphenol-rich seaweed (Eucheuma cottonii) extract suppresses breast tumour via hormone modulation and apoptosis induction. *Food Chemistry*, 130, 376-382.

Nathera M.A., H., Hazilawati, S., Jasni, M.M., Noordin, S. Shahirudin, and S.M., Rosly 2009. Invasive lobular carcinoma in rats following intramammillary exposure to dibenzo (a, l) pyrene. Proceeding of the International Conference on Animal Health and Human Safety

Noordin, M.M. (1988). *The toxicity of Brachiaria decumbens.* Thesis of MSc, Universiti Putra Malaysia.

Noordin, M.M. (1996). Trace element research in sheep in Malaysia. *The Australian Centre for International Agricultural Research* (*ACIAR*) *Proceedings,* 73, 72-77.

Noordin, M.M. (2008). The Emergence of Neutraceuticals. *2nd Global Bio-Herb Economic Forum (GBHEF) 2008*, 15th-17th November 2008, Putrajaya International Convention Centre (PICC), Malaysia.

Noordin, M.M. (2013). Nipah Virus infection: naturally occurring infection. *Symposium on Animal Disease Control*, CADIC, 13 July 2013, Miyazaki, Japan

Noordin, M.M. (2015). Malaysia Preparedness in Controlling Outbreaks of HPAI. *Symposium on Animal Disease Control*, CADIC, 11 November 2015, Miyazaki, Japan

Noordin, M.M. (2016). Problems and Solutions in Handling Trans-boundary Zoonoses. *Symposium on Solutions to Emerging and Zoonotic Diseases*, Vietnam National University of Agriculture, 25-26 August 2016, Hanoi, Vietnam.

Noordin, M.M., Azlan, C.M., Shahirudin, S. and Jasni, S. (2009). An outbreak of inclusion body disease (IBD) in boid in Malaysia Paper presented at: Malaysian Association of Veterinary Pathology Conference 2009; Sarawak, Malaysia.

Noordin, M.M., Abdullah, A.S. and Rajion, M.A. (1989). Experimental Brachiaria decumbens toxicity in cattle. *Veterinary Research Communications*, 13, 491-494.

Noordin, M.M., Ragavan, K., Shahirudin, S., Azam-Khan, G.K., Zeenathul, NA., Arshad, S.S.A and Kamarudin, A.I (2010). Emerging diseases of goats in Malaysia. *Pertanika Journal of Tropical Agricultural Science, 33*, 123-126.

Noordin, M.M., Zhang, S.Z., Rahman, S.O.A and Haron, MD. J. (2000). The concentration of selected minerals and phytate in malaysian Brachiaria decumbens *Veterinary and Human Toxicology*, *42*, 276-279.

Noordin, M.M., Salam Abdullah, S.A. and Rajion, M.A. (1989). Experimental *Brachiaria decumbens* toxicity in cattle. *Veterinary Research Communications, 13*, 491–494.

Noordin, M.M., Sanaz, M., Teh-Rasyidah, I., Wan-Mazlina, M.S., Thoria, A.H., Sheikh-Omar, A.R. & Hassan, M.D. (2004). Studies on the effects of selected PAH found during the 1997 haze episode in rats. *National Environmental Seminar 2020: Urban Environment*, 28-29 September 2004, Mines Beach Resort, Seri Kembangan, Selangor, Malaysia

Noordin, M.M., Zamri-Saad, M., Salam Abdullah, A. and Rajion, M.A. 1987. Effects of grazing of *B. decumbens* on the ultrastructure of liver and kidney of sheep. *Kajian Veterinar, 19*, 215-218.

Norina, L., Sabri, M.Y., Goh, Y.M., Zamri-Saad, M., Sarenasulastri, A.B., Latifah, H., Jamilah, H. and Noordin, M.M. (2011). Immunohistological localisation of Coxiella burnetii in various organs of naturally Q-Fever infected goats. *Pertanika Journal of Tropical Agricultural Science*, *34*,167-173.

Nurul, S.A.S., Hazilwati, H., Sajjarattul, N.N.A., Huthefya, A.H., Rosly, H.M., Wan, S.W.Z., Norhaizan, M.E., Shammuganvelu, S., Noordin, M.M. and Jasni, S. (2016).Low level of cyclooxygenase-2 transcript in the spleen lymphoma rats supplemented with garlic powder. *Asian Journal of Pharmaceutical and Clinical Research*, *9*, 6p.

Pope, C. Ar. (1996). Particulate pollution and health: A review of the Utah valley experience. *Journal of Exposure Analysis and Environmental Epidemiology*, *6*, 23-34.

Rosalina Tan, R.T., S., Mohamed, G.F., Samaneh, M.M., Noordin, Y.M., Goh, and M.Y.A., Manap, 2011. Polyphenol rich oil palm leaves extract reduce hyperglycaemia and lipid oxidation in STZ-rats. *International Food Research Journal. 18*,179-188.

Ruslay, S., Abas, F., Shaari, K., Zainal, Z., Muliadani Sirat, Israf, D.A. and lajis, N.H. (2007). Characterization of the components present in the active fractions of health gingers (Curcuma xanthorrhiza and Zingiber zerumbet) by HPLC–DAD–ESIMS. *Food Chemistry*, *104*,1183–1191.

Shalan, N.A.A.M., N.M., Mustapha, and S., Mohamed. 2016. Morinda citrifolia leaf enhanced performance by improving angiogenesis, mitochondrial biogenesis, antioxidant, anti-inflammatory & stress responses. *Food Chemistry*, *212*, 443-452.

Shukri, R., S., Mohamed, and N.M., Mustapha, 2010. Cloves protect the heart, liver and lens of diabetic rats. *Food Chemistry*, *122*, 1116-1121.

Shukri, R., Mohamed, S., Mustapha, N.M. and Hamid, A.A. (2011). Evaluating the toxic and beneficial effects of jering beans (Archidendron jiringa) in normal and diabetic rats. *Journal of the Science of Food and Agriculture*, *91*, 2697-2706.

Song L, Leung C, Schindler C (2001). Lymphocytes are important in early atherosclerosis. *Journal of Clinical Investigation*, *108*, 251–259.

Schulze, P.C. and Lee R.T. (2005). Oxidative stress and atherosclerosis. Current Atherosclerosis Reports, *7*, 242–248.

Tee, P.L., Yusof, S., S., Mohamed, N., Aimi Umar and M.M., Noordin, 2002. Effect of roselle (Hibiscus sabdariffa L.) on serum lipids of Sprague Dawley rats. *Nutrition and Food Science, 32*,190-196.

Thompson, R.G. (1984). General Veterinary Pathology. W.B. Saunders, Philadelphia, 2nd Edition, 480pp

Tong, C.C., Choong, Y.K., Umar, N.A.B., Noordin, M.M. and Mohamed, S. (2008).Efficacy of Ganoderma lucidum on plasma lipids and lipoproteins in rats fed with high cholesterol diet. *Nutrition and Food Science*, *38*, 229-238.

Tong, C.C., Choong, Y.K., Umar, N.A.B., Noordin, M.M. and Mohamed, S. (2009). Cytotoxic activity induced by crude extracts of Ganoderma lucidum (W. Curt.: Fr.) P. Karst. on mouse myeloma cancer cell-line. *World Journal of Microbiology and Biotechnology*, *25*, 687-695.

Verein D. I. (1997). VDI-Richtlinien, Messen von Partiklen, Gravimetrische Bestimmung der Messenkonzentration von Partikel in der Aussenluft, Grundlagen. Blatt 1 Entwurf 1997, Berlin.

Wang, Y.X., Niu, J.P., Ding, G.W., Noordin, M.M., & Chen, X.Y. (2007a). Current situation on health respiratory system of primary and middle school students in Lanzou. *Chinese Journal of Public Health, 23*, 666-668.

Wang, Y.X., Niu, J.P., Ding, G.W., Noordin, M.M. & Chen, X.Y. (2007b). Effect of air-pollution towards the immune system of puberty youth. *Chinese Journal of School of Health, 28*, 560-561

Wang, Y.X., Niu, J.P., Ding, G.W., Noordin, M.M., & Chen, X.Y. (2007c). Effects of air pollution on juvenile lung function in Lanzhou, China. *Journal of Environmental Health, 24*, 415-417.

Wozniak, E., McBride, J., DeNardo, D., Tarara, R., Wong, V. and Osburn, B. (2000). Isolation and characterization of an antigenically distinct 68-kd protein from nonviral intracytoplasmic inclusions in Boa constrictors chronically infected with the inclusion body disease virus (IBDV: Retroviridae). *Veterinary Pathology, 37*, 449-59.

Zhang, S.Z., M.M., Noordin, S.O., Rahman, and J., Haron. 2000. Effects of copper overload on hepatic lipid peroxidation and antioxidant defense in rats. *Veterinary and Human Toxicology*, *42*, 261-264.

Zhang, S.Z., M.M., Noordin, S.-O.A., Rahman, and J., Haron, 2001. The effect of zinc supplementation on antioxidant and lipid peroxidation status during Brachiaria decumbens intoxication in sheep. *Veterinary and Human Toxicology*, *43*, 83-87.

BIOGRAPHY

Noordin Mohamed Mustapha, a Penangite, was born on 26th May. He was among the last batch of schoolchildren who had their science and mathematics taught in English. Schooling years were at the Wellesley Primary School, Gelugor Secondary School, Jelutong Secondary School and Methodist Boys School, all in Penang. Noordin went on to graduate with a DVM and MSc (Biomedical Pharmacology) from Universiti Pertanian Malaysia and a PhD (Toxicopathology) from Murdoch University. He began his academic career (April 1986-September 1987) as a demonstrator for physiology, pharmacology and pathology practicals for the Doctor of Veterinary Medicine (DVM) and Diploma in Animal Health and Production (DAHP) students.

From October 1987 until January 1988, his teaching was focused only on pathology, to the DVM and DAHP students. From June 1992 to May 1995, apart from teaching pathology, he coordinated a course on public health for the DAHP students. However, beginning from May 1995, his lectures were confined to general and systemic pathology, to the DAHP, DVM and Biomedical students. He uses innovative teaching methods (creation of disease models and play/sketches) to inculcate long term memory in learning. These innovations were appreciated by UPM where the effort was bestowed UPM's prestigious awards, namely, the Anugerah Pengajaran Putra (2009) & Vice-Chancellor's Fellowship (2010). Noordin has also been an examiner for the final year DAHP, an external examiner for veterinary attendants at Institut Veterinar Malaysia, Kluang, and has been assisting with the running of the DVM final year comprehensive examinations.

In 2003, following his contributions on haze mitigation during sabbatical leave, he was conferred an honorary professorship by Lanzhou Medical College, China. Subsequently, Lanzhou

University (2008) awarded him their very first foreign adjunct professorship in Environmental and Nutritional Health under the prestigious Chui Yin's chair. In June 2010, he was made the visiting professor to the Faculty of Veterinary Medicine, Hanoi University of Agriculture, Hanoi, Vietnam. Currently (2013-2017) Noordin is a fellow to the Centre for Animal Disease Control (CADIC), University of Miyazaki, Japan, a centre similar to the regional CDC in Japan.

Just prior to going on sabbatical leave in 2003, he was the Coordinator of the university's Centre of Excellence for Ruminant Research and the faculty's Scrutiny Board immediately upon completion of his term as the Head of the Department of the Veterinary Pathology and Microbiology, from November 2006 until October 2008 and December 2012- November 2015.

During his first tenure as the Head he successfully spearheaded the department, faculty and university to have the first two laboratories (Bacteriology and Biologics) in the nation's institute of higher learning (IHL) accredited with ISO/IEC 17025. He also initiated an MoA between the University of Miyazaki, Japan with UPM in 2013.

Noordin is a panel member of the Ministry of Education FRGS, UPM and UMK Research Application Boards(Medicine and Veterinary Field) as well asa member of the Department of Veterinary Services Malaysia Veterinary Protocol documentation team.

As a full-time diagnostic pathologist, he has reported the nation's first occurrences of caprine molybdenosis, selenium deficiency, canine distemper (seals), caprine-associated malignant catarrhal fever (deer), inclusion body disease in boids, caprine coenuriasis and caprine arthritis encephalitis and hepatogenous chronic copper poisoning.

Noordin's research interests encompass the effects of plant toxicity, air quality on health, BIBD, emerging and re-emerging diseases, nutraceuticals, nutrient excess or deficiency and the ultilisation of chelation therapy in environmental intoxication, with particular emphasis on biochemical, histologic, ultrastructural and molecular correlations. Noordin has been invited seven(7) times to present reviews of current research at the international level. His knowledge in pathology with respect to other fields of study is always being utilised to the maximum (collaborative and networking projects). He has successfully guided more than 50 undergraduates for their final year projects. As for postgraduate studies, he has efficiently supervised 14 PhD and 13 MVSc/MS students. His supervision of both undergraduates and postgraduates is not only confined to this faculty but also extended to those from the Faculty of Food Science and Bioscience Institute. The fields supervised include nutritional pathology, environmental pathology, virology, bacteriology, parasitology, emerging diseases and nutraceuticals.

Noordin has been involved in several contract research projects dealing with herbal efficacy and toxicity. In view of his strength in nutraceutical research, a leader in Malaysian herbal products that is multinational in its market distribution appointed him as its International Technical/Scientific Advisory Board member. The role is not only to conduct research but to venture into opportunities in product improvement and innovation. Additionally, a subsidiary to the company, HEWO, has also appointed him as their panel board member.

Based on his extensive research in environmental health, his views and ideas have been sought by the School of Public Health, Lanzhou Medical College, Lanzhou, PR China, for assistance with their air pollution problem. The relationship has been very successful whereby the school, for the very first time, managed to

secure one of the biggest research grants amounting to 500,000 RMB for a two year project. Due to his tireless efforts he was bestowed an honorary professorship to the school in 2003. Later, Noordin was awarded the most prestigious professorial chair (Chui Yin's) of Lanzhou University, in the field of Environmental and Nutritional Health in 2007.

Noordin's efforts in the academic field have been unequivocally balanced by active participation in professional and non-government organisations. He has been a business manager, secretary, subeditor of a local journal and also the secretariat for professional organisation's conferences.

ACKNOWLEDGEMENTS

Glory to Allah most high, full of grace and mercy, HE created all and gave us a special place in HIS creation. HE honoured us to be HIS agents and endued us with knowledge and understanding, purified affections and spiritual insights so that we understand nature and ourselves. Alhamdulillah, the Almighty Creator has bestowed upon us a provision with HIS utmost graciousness and mercifulness, to be on the path of an educator who is promised to be perpetually blessed with baraqah.

I would like to extend my greatest gratitude to principal officers of UPM, led by Yang Berbahgia Profesor Datin Paduka Dr. Aini Ideris, for their effort and dedication in enabling UPM to soar upwards. A million thanks for the support and encouragement rendered by the faculty's management team headed by Prof. Dr. Mohd Hair Bejo and his deputy Assoc. Prof. Dr. Zunita Zakaria, Assoc. Prof. Dr. Siti Suri Arshad, Assoc. Prof. Dr. Gurmeet Kaur Dhaliwal and the other six heads of departments.

Not to forget others from all walks of life who have directly or indirectly created a conducive environment within this faculty and UPM, pertaining to academic needs. I am deeply indebted to Prof. Dato' Dr. Sheikh Omar Abdul Rahman, Prof. Dr. Mohd Ali Rajion, Prof. Dato' Dr. Mohd Azmi Mohd Lila, Prof. Dr. Suhaila Mohamed, Prof. John McHowell and Allahyarham Prof. Dato' Dr. Abdul Salam Abdullah, for their constant encouragement, patience and tolerance in guiding me towards building a successful academic career.

Not to forget my other colleagues at UPM, UMK, Lanzhou University, University of Miyazaki, Vietnam National University of Agriculture, University of Chulalongkorn, University of Tokyo, University of Cambridge and Cornell University, who share the same ideas, thoughts and determination in giving the very best to

the academic world, namely, Prof. Dr. Jasni Sabri, Prof. Dr. Mohd Azam Khan and Dr. K. Ragavan, Assoc. Prof. Dr. Rosnina Hj Yusoff, Prof. Niu Jinping, Prof. Ryoji Yamaguchi, Dr. Nguyen Thi Lan, Prof. Dr. Roongroje Thanawongnuwech, Prof. Hiroyuki Nakayama, Prof. Alun Williams and Prof. Gerard Duhamel. I am also grateful for the enthusiastic and competent technical aid of the postgraduates (Drs. Shizhen Zhang, Sanaz Movassagh, Latif Khadim, Kareem Jaafar, Ibrahim Abdulazees Okene, Omar Emad Ibrahim, Ajwad Assumaidaee, Nabil Mirwan Althabet, Hemn Othman, Yasameen Shahib, Rabiu Aliyu, Nisha Ravindran, Yusuf Abba, Yusuf Ilyasu, Thoria Abdel Hameed, Nisha, Norina Lokman, Hasliza Hassim, Mazlina Mazlan, Imilia Ismail, Azlina Ahmad, Wan Mazlina Saad, Teh Rasyidah Rashid, Pham Hong Trang, Roslina Hassan) that has led to the churning of breakthroughs and publications.

I would further like to take this opportunity to thank all colleagues, especially those at the necropsy building, namely Mr. Ghazali Mohd Yusof, Mr. S. Apparao, Mr. Najib Yahya, Mrs. Jamilah Jahari, Mrs. Latifah Mohd Hanan, Dr. Mazlina Mazlan, Dr. Annas Salleh and Dr. Aliff Asri, for their understanding, generosity and kind cooperation. Thanks also to Mr. Muhammad Akees Abu Mansor, Mr. Wan Mohd Azwaar Wan Hassan, Ms. Amiratul Azlin Husaini Amir, Mr. Muhamad Zaid Nor Akahbar, Dr. Mazlina Mazlan, Dr. Annas Salleh and Dr. Mohd Faiz Nik Mohd Azmi for endeavouring to make this event a success.

Last but not least, my beloved wife Norizah Zakaria-Zainuddin, my children, Muhammad Noorhafiz Noordin, Norhidayah Noordin and Muhammad Noorhadi Noordin, my in-laws, niece and nephew for their unfailing support, encouragement and for accepting my frequent absences from the family that my commitment to this career has necessitated.

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