LIVESTOCK BREEDING
THE PAST, THE PRESENT AND THE FUTURE

PROFESSOR DR. ABD WAHID HARON

LIVESTOCK BREEDING
THE PAST, THE PRESENT AND THE FUTURE

Prof. Dr. Abd Wahid Haron
PhD (UCD, Dublin), DVM (UPM, Malaysia)

9 December 2013

Auditorium,
Fakulti Perubatan Veterinar
Universiti Putra Malaysia

Universiti Putra Malaysia Press
Serdang • 2013
http://www.penerbit.upm.edu.my

First Print 2013

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

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

Contents

ABSTRACT

Successful livestock breeding until production of a healthy offspring is one of the key factors in ensuring sustainable animal production. The use of assisted reproductive biotechnology such as artificial insemination has always been practiced in ruminant sectors worldwide but its application in Malaysia is limited among farmers who are able to envisage the benefit of the technology in upgrading the genetic quality of their animals. The success of artificial insemination involves many factors such as semen collection, semen cryopreservation, handling of cryopreserved semen, insemination time and establishment of pregnancy. Therefore, this lecture dwells around research findings in the many processes in semen collection and cryopreservation which eventually improving the quality of semen prior to artificial insemination. It also discusses other aspects of livestock breeding such as oestrus synchronization and pregnancy diagnosis as well as in vitro embryo production.

INTRODUCTION

In all over the world, livestock production and the demand for livestock products continues to rise due to the steady growth of world's population which is expected to reach 10 billion by 2050. The demand for livestock products in Malaysia is also in the increasing trend. To date, Malaysia continue to meet its self-sufficiency level in two livestock namely pigs and poultry. In pigs, the self-sufficiency level is growing steadily at 99.24% (2011) to 100.51% (2011), while in poultry is at 113.68% (2001) to 128.14% (2011) (DVS, 2013).

On the other hand, the per capita consumption of livestock products is also continue to increase not only for pigs and poultry but also for other livestock products. This is evidence in the per capita consumption of beef, from 5.01 kg (2001) to 5.71 kg (2011) and, mutton/chevon, from 0.66 kg (2001) to 0.83 kg (2011) (DVS, 2013). Domestic farm animals, including cattle, sheep and goats, are important to the world economy. They are also very important livestock to smallholder farmers in developing countries such as Malaysia for their meat and milk. Like other countries, the ruminant population especially cattle and goats have been steadily increasing over the past ten years in Malaysia. The total population of cattle and goats in Malaysia was estimated at 855,543 and 523,800 heads in 2011 (DVS, 2013), respectively. This statistics is still far from fulfilling the requirement of the country and will certainly face with many challenges in satisfying the need of more than 32 million Malaysian in 2020. One of the strategies is to adopt and implement proper planned and assisted breeding in livestock particularly in the ruminant sector.

Malaysia: Self-Sufficiency in Livestock Products (%), 2001-2011

KOMODITI *Commodity*	WILAYAH *Region*	2001	2002	2003	2004	2005	2006	2007	2008	2009[P]	2010[P]	2011[E]
DAGING LEMBU/ KERBAU *Beef*	**Malaysia**	**16.06**	**17.89**	**18.49**	**17.95**	**21.15**	**21.78**	**23.50**	**25.38**	**26.98**	**28.65**	**29.02**
	S. Malaysia	16.98	18.74	18.49	18.33	22.17	22.93	25.10	26.62	27.78	29.99	30.38
	Sabah	17.32	12.66	18.49	21.28	7.52	19.97	7.45	9.38	20.03	10.77	11.00
	Sarawak	4.96	7.00	18.49	8.07	13.30	6.90	6.29	9.03	10.79	11.46	11.62
DAGING KAMBING/BEBIRI *Mutton*	**Malaysia**	**5.94**	**7.70**	**10.36**	**8.76**	**8.60**	**8.99**	**9.57**	**10.04**	**10.32**	**10.58**	**11.28**
	S. Malaysia	5.68	7.65	10.53	8.73	8.67	9.04	9.60	10.10	10.39	10.67	11.35
	Sabah	td	td	td	td	td	td	td	td	td	td	td
	Sarawak	6.15	9.23	6.93	9.75	6.75	7.69	8.79	8.56	8.69	8.36	9.50
DAGING BABI *Pork*	**Malaysia**	**99.24**	**98.68**	**99.32**	**99.56**	**96.82**	**96.87**	**96.91**	**96.61**	**96.88**	**101.69**	**100.51**
	S. Malaysia	98.91	98.24	99.15	98.97	96.14	95.19	96.07	95.55	96.11	100.67	99.59
	Sabah	99.89	99.96	100.63	100.00	99.97	102.63	99.99	99.98	100.78	102.14	104.56
	Sarawak	101.18	101.06	99.91	102.43	100.00	104.76	100.27	101.37	100.16	107.30	104.61
DAGING AYAM/ITIK *Poultry Meat*	**Malaysia**	**113.88**	**109.40**	**107.74**	**107.80**	**124.74**	**124.94**	**121.77**	**121.94**	**122.22**	**127.89**	**128.14**
	S. Malaysia	66.10	112.22	110.85	110.12	131.15	132.45	128.25	127.41	126.24	132.08	132.20
	Sabah	82.05	75.81	72.34	81.51	77.00	84.74	74.99	78.86	91.25	97.98	100.70
	Sarawak	100.00	100.00	101.11	100.00	91.76	95.74	87.43	90.20	91.21	95.43	95.63
TELUR AYAM/ITIK *Chicken/Duck Eggs*	**Malaysia**	**112.39**	**115.29**	**113.82**	**111.70**	**108.70**	**109.06**	**111.38**	**112.30**	**114.72**	**115.40**	**117.70**
	S. Malaysia	114.78	119.03	116.68	124.61	105.25	109.78	115.30	110.77	117.49	118.17	120.53
	Sabah	100.00	99.80	100.00	101.50	289.44	112.86	101.20	202.53	114.29	114.98	117.45
	Sarawak	100.84	100.00	100.00	100.00	100.34	100.29	87.78	97.78	91.50	92.05	93.92
SUSU *Milk*	**Malaysia**	**2.24**	**2.83**	**2.86**	**2.98**	**4.59**	**4.66**	**4.79**	**4.89**	**4.88**	**4.88**	**5.00**
	S. Malaysia	2.46	2.30	2.44	2.56	3.85	4.00	3.75	4.40	4.37	4.36	4.47
	Sabah	39.23	84.69	86.09	36.17	87.36	46.32	71.47	44.33	88.89	89.07	91.34
	Sarawak	0.69	0.65	2.17	2.05	2.29	1.82	2.08	2.18	1.57	1.70	1.65

P : Sementara (Provisional) E : Anggaran (Estimate) td : Tiada maklumat *(Not available)*

(*Source:* Department of Veterinary Services Malaysia, 2013)

Malaysia: Per Capita Consumption of Livestock Products, 2001-2011

KOMODITI *Commodity*	WILAYAH *Region*	2001	2002	2003	2004	2005	2006	2007	2008	2009[P]	2010[P]	2011[E]
DAGING LEMBU/ KERBAU *Beef (Kg)*	**Malaysia**	**5.01**	**5.06**	**5.18**	**5.81**	**5.32**	**5.49**	**5.48**	**5.43**	**5.60**	**5.75**	**5.71**
	S. Malaysia	5.56	5.77	5.71	6.85	6.15	6.38	6.28	6.35	6.64	6.69	6.56
	Sabah	1.64	1.66	3.46	0.91	2.11	1.49	1.86	1.47	0.78	1.59	1.54
	Sarawak	4.38	3.01	2.59	2.81	1.51	2.78	3.00	2.42	2.53	2.59	2.59
DAGING KAMBING/BEBIRI *Mutton (Kg)*	**Malaysia**	**0.66**	**0.60**	**0.50**	**0.59**	**0.65**	**0.67**	**0.68**	**0.70**	**0.75**	**0.80**	**0.83**
	S. Malaysia	0.79	0.73	0.60	0.72	0.79	0.81	0.83	0.85	0.91	0.96	1.00
	Sabah	td	td	td	td	td	td	td	td	td	td	td
	Sarawak	0.31	0.22	0.27	0.19	0.28	0.28	0.29	0.30	0.32	0.34	0.36
DAGING BABI *Pork (Kg)*	**Malaysia**	**7.75**	**7.97**	**7.67**	**7.86**	**8.63**	**8.40**	**7.60**	**7.28**	**7.62**	**8.15**	**7.80**
		**** 19.38**	**** 19.92**	**** 19.19**	**** 19.65**	**** 21.58**	**** 21.00**	**** 19.00**	**** 18.20**	**** 19.06**	**** 20.36**	**** 19.50**
	S. Malaysia	8.11	8.30	7.70	7.89	7.75	8.61	7.52	7.41	7.80	8.34	8.00
		** 20.28	** 20.76	** 19.26	** 19.73	** 19.38	** 21.52	** 18.79	** 18.52	** 19.49	** 20.86	** 20.01
	Sabah	3.30	3.00	2.90	4.30	4.50	4.20	3.20	3.50	2.45	2.72	2.46
					** 7.28	** 7.67	** 7.32	** 7.74	** 6.65	** 6.13	** 6.80	** 6.16
	Sarawak	12.53	11.95	14.31	14.03	13.29	15.35	16.11	12.20	12.74	13.31	13.36
					** 35.08	** 33.23	** 34.15	** 35.20	** 30.50	** 31.84	** 33.28	**33.41
DAGING AYAM/ITIK *Poultry Meat (Kg)*	**Malaysia**	**28.03**	**31.88**	**31.85**	**33.63**	**30.07**	**31.11**	**33.24**	**34.38**	**35.26**	**35.86**	**35.34**
	S. Malaysia	30.18	35.60	35.22	37.43	32.66	32.33	36.00	37.68	39.01	39.66	39.19
	Sabah	21.64	17.05	18.93	18.53	19.04	28.32	19.23	18.08	15.71	16.04	15.49
	Sarawak	16.90	17.54	1.82	19.13	21.12	23.80	26.84	26.10	26.67	27.08	26.80
TELUR AYAM/ITIK * *Chicken/Duck Eggs (Egg)*	**Malaysia**	**251**	**248**	**251**	**253**	**260**	**267**	**271**	**280**	**290**	**301**	**299**
		***** 15.04**	***** 14.88**	***** 15.08**	***** 15.18**	***** 15.60**	***** 16.01**	***** 16.26**	***** 16.79**	***** 17.38**	***** 18.08**	***** 17.92**
	S. Malaysia	262	250	261	265	278	279	279	294	306	319	316
	Sabah	196	192	175	163	48	161	132	72	147	154	149
	Sarawak	208	302	250	265	251	267	321	313	324	336	335
SUSU *Milk (Kg)*	**Malaysia**	**56.07**	**51.73**	**51.08**	**50.84**	**34.26**	**36.63**	**39.27**	**41.67**	**45.74**	**48.61**	**48.06**
	S. Malaysia	53.52	67.84	63.06	62.89	42.52	45.18	48.47	51.54	56.84	60.39	59.86
	Sabah	4.53	2.23	2.35	5.50	2.65	4.94	5.20	4.46	2.49	2.65	2.57
	Sarawak	6.13	6.36	1.46	1.29	1.13	1.17	1.20	1.33	1.55	1.64	1.63

P : Sementara (Provisional)
E : Anggaran (Estimate)
td : Tiada maklumat *(Not available)*

** Berdasarkan kepada 40% bilangan penduduk bukan Islam
** *Based on total consuming population of 40% non-Muslim*
*** : Kg

* Anggaran purata berat telur ayam/itik = 60 gm/biji
* *Estimated average weight of chicken/duck egg = 60 gm/egg*

(*Source:* Department of Veterinary Services Malaysia, 2013)

Malaysia: Livestock Population, 2007-2011

JENIS TERNAKAN *Livestock Type*	2007	2008	2009	2010	2011[E]
KERBAU *(Buffalo)*					
S.Malaysia *(P. M'sia)*	80,931	79,661	74,979	72,799	71,913
Sabah	42,157	43,422	44,200	44,642 [P]	45,088
Sarawak	7,687	8,146	7,973	7,734 [P]	7,502
Jumlah *(Total)*	**130,775**	**131,229**	**127,152**	**125,175**	**124,503**
LEMBU *(Cattle)*					
S.Malaysia *(P. M'sia)*	772,323	779,877	786,317	761,796	778,189
Sabah	57,944 [R]	57,745 [R]	60,191 [R]	61,395 [P]	62,623
Sarawak	11,919 [R]	13,605 [R]	13,983	14,352 [P]	14,731
Jumlah *(Total)*	**842,186**	**851,227**	**860,491**	**837,543**	**855,543**
KAMBING *(Goat)*					
S.Malaysia *(P. M'sia)*	373,319	419,720	452,467	432,085	460,728
Sabah	45,742	45,742	47,110	47,779 [P]	48,457
Sarawak	9,202	12,018	14,656	14,635 [P]	14,615
Jumlah *(Total)*	**428,263**	**477,480**	**514,233**	**494,499**	**523,800**
BEBIRI *(Sheep)*					
S.Malaysia *(P. M'sia)*	122,106	125,931	130,723	118,300	117,108
Sabah	1,970	1,989	2,009	2,029 [P]	2,049
Sarawak	1,912	3,358 [R]	3,553	3,020 [P]	2,567
Jumlah *(Total)*	**125,988**	**131,278**	**136,285**	**123,349**	**121,724**
BABI *(Swine)*					
S.Malaysia *(P. M'sia)*	1,441,036	1,407,195	1,401,190	1,462,814	1,466,747
Sabah	82,200	105,075	83,972	77,926 [P]	72,315
Sarawak	496,881	476,619 [R]	346,146	339,569 [P]	333,117
Jumlah *(Total)*	**2,020,117**	**1,988,889**	**1,831,308**	**1,880,309**	**1,872,179**

P : Sementara (Provisional) E : Anggaran (Estimate) R : Semakan Semula (Revised)

(*Source:* Department of Veterinary Services Malaysia, 2013)

ASSISTED REPRODUCTIVE BIOTECHNOLOGY

Over the last two decades, various assisted reproductive biotechnology (ARB) are commonly applied in animal production to enhance their reproductive capacity, improve and preserve livestock genetics and develop new products such as transgenic or cloned animals.

The use of ARB has become increasingly widespread in livestock industry. The acceptability of cryopreservation of semen and embryo, artificial insemination, in vitro embryo production, and embryo transfer have led to establishment of many breeding organizations, semen and embryo banks, as well as sire stations. This is especially true in the dairy and beef cattle industry, where semen and embryo technological advancements have been the

most successful and widely used. However, the resulting quality of cryopreservation in many species is not similar to that of the initial specimen collected and face with many challenges.

ARTIFICIAL INSEMINATION

Assisted reproductive biotechnologies (ARB) are necessary to accelerate the efficiency of reproduction especially in ruminant. Amongst all ARBs, artificial insemination (AI) is the most effective technology for upgrading the breed and improving the reproductive rates in domestic animals. Artificial insemination has been used extensively in livestock production especially in cattle. It has also been used as a tool for genetic improvement programs, the introduction of specialized breeds, development of selected programs and progeny testing. Therefore, the use of AI serve as a better option for increasing the reproductive performance and upgrading of existing ruminant breed in this country.

Although natural mating is still preferred by many ruminant farmers, many farmers develop interest to breed their animals using AI and therefore good quality cryopreserved semen is needed to ensure the animal is pregnant following AI. This requires proper establishment of the current techniques of processing, cooling, packaging and freezing of semen which will enhance the subsequent viability and fertility of spermatozoa. Several factors many contribute to the low fertility with cryopreserved semen, which include cold-shock, osmotic stress and oxidative stress. All these are related to the procedures of cryopreservation that lead to spermatozoa damage, impairs its function and fertilizing potential.

In Malaysia, AI in cattle has been introduced since 1960's. Its widespread use is still faced with many challenges and are limited to farmers who are capable of seeing the advantage of using AI in upgrading their animals. One of the most important factors in

assuring the success of AI is the ability to produce good quality semen obtained from superior quality males and subsequently maintained either chilled or frozen thawed prior to AI. The basic principle of chilling or freezing is similar for spermatozoa of most mammalian species, but spermatozoa from different species may react differently due to their differences in morphology and certain biochemical constituents. It is worth mentioned that cryopreservation of goat semen differs from that of the other species, such as bull, boar, or ram. This is because the seminal plasma of goat's semen contains phospholipase secreted by the bulbourethral gland. It interacts with egg yolk resulting in coagulation of egg yolk media and hydrolyses lecithin to fatty acids and spermicidal lysolecithins (Leboeuf *et al*., 2000). Hence, cryopreservation protocol developed for one species may not be ideal for spermatozoa of other species (Sundararaman and Edwin, 2008). Various researchers reported successful cryopreservation of goat spermatozoa but the fertility rate with chilled and frozen stored goat spermatozoa is variable. Many steps involve in the entire process of semen cryopreservation such as collection, washing, dilution, cooling, equilibration, freezing and thawing, and during which spermatozoa may eventually lose its ability to fertilize normally. Therefore, cryopreservation protocols for ruminant semen particularly goats raised in this country should be developed with the aim to maximize the quality and minimize the losses during cryopreservation.

SEMEN COLLECTION

As indicated earlier that semen must be collected, evaluated and cryopreserved prior to artificial insemination. Successful artificial insemination depends on many factors not only the exact time of insemination but also the quality of collected and cryopreserved semen. Several semen collection techniques such as using artificial

vagina and electro-ejaculation have been noted to produce good quality semen in livestock as well as wildlife animals.

It has been showed that semen can be collected safely from anesthetized lesser mouse deer using electro-ejaculation. The semen characteristics of this species were similar to those of semen collected by electro-ejaculation from other ruminants (Haron *et al*., 2000). Apart from that, the morphology was also evaluated and measured. The spermatozoon in the lesser mouse deer is smaller than ram (Evans and Maxwell, 1987) and bull (Salisbury and Van Demark, 1985) with the head is relatively more round compared to the other ruminants (Prasetyaningtyas *et al*., 2006).

In another study, it has been indicated that electro-ejaculation can be used to obtain semen from untrained (*Bos javanicus*) Bali bulls with 100% success rate and perhaps regarded as the preferred method since it requires relatively shorter time prior to collection. Electro-ejaculation also provide acceptable post-thawed semen quality that would permit faster reproduction and conservation of the Bali cattle (Sarsaifi *et al*., 2013).

Percentage response, penile protrusion and semen emission of Bali bulls subjected to three semen collection methods

Parameters	Method of semen collection		
	EE (n = 25)	RM (n = 25)	RM + EE (n = 25)
No. of bulls responded to collection method (%)	25 (100)[a]	21 (84)[b]	24 (96)[a]
No. of bulls displayed penile protrusion (%)	24 (96)[a]	20 (80)[b]	23 (92)[a]
Time required for penile protrusion (s)	55.14 ± 1.22[b]	80.08 ± 1.78[a]	49.40 ± 0.28[b]
Time required for semen emissions (s)	76.30 ± 1.95[b]	116.77 ± 3.93[a]	70.27 ± 0.67[b]
No. of electrical stimuli required for penile protrusion	14.43 ± 0.76	NA	13.85 ± 1.92
No. of electrical stimuli required for semen emission	23.20 ± 0.97	NA	22.12 ± 2.31

NA, not applicable.
Mean values with different superscripts in the same row are significantly different at $p < 0.05$.

(Sarsaifi et al., 2013)

Semen parameters of Bali bulls subjected to three semen collection methods

Semen parameters	Method of semen collection (mean ± SEM)		
	EE	RM	RM + EE
Volume (ml)	6.98 ± 0.29[a]	3.85 ± 0.19[b]	6.97 ± 0.22[a]
pH	7.04 ± 0.31[a]	6.88 ± 0.37[b]	7.05 ± 0.03[a]
General motility (%)	74.44 ± 1.73	73.83 ± 1.46	74.52 ± 1.78
Viability (%)	72.54 ± 1.60	71.36 ± 2.85	71.04 ± 1.49
Sperm concentration ($\times 10^6$)	688.98 ± 18.3[b]	831.55 ± 20.70[a]	685.63 ± 14.67[b]
Acrosome integrity (%)	73.73 ± 1.63	74.05 ± 0.91	72.81 ± 1.23
Normal morphology (%)	73.14 ± 1.24	71.50 ± 1.71	72.02 ± 1.30
Sperm head defects (%)	6.29 ± 0.34	6.02 ± 0.40	6.98 ± 0.42
Detached sperm heads (%)	3.67 ± 0.30	4.44 ± 0.31	4.33 ± 0.31
Sperm midpiece defects (%)	3.08 ± 0.28	3.41 ± 0.23	3.54 ± 0.46
Proximal cytoplasmic droplet (%)	3.94 ± 3.02	4.92 ± 3.09	4.85 ± 0.25
Tail abnormality (%)	9.90 ± 0.44	9.33 ± 0.76	10.33 ± 0.52

Means values in the same rows with different superscripts are significantly different at $p < 0.05$.

(Sarsaifi et al., 2013)

Effects of method of collection on acrosomal integrity and parameters calculated by CASA system for fresh and frozen-thawed semen in Bali bulls

Semen sample	Fresh		Frozen	
	Semen collection method			
Semen quality parameters	EE	RM	EE	RM
General motility (%)	77.43 ± 2.75	76.53 ± 2.18	63.80 ± 1.89[b]	67.90 ± 0.53[a]
Progressive (%)	68.80 ± 2.36	67.25 ± 1.63	50.46 ± 1.99[b]	56.73 ± 0.65[a]
VAP (μm/s)	101.82 ± 1.28	103.14 ± 2.69	74.90 ± 1.38[b]	80.20 ± 1.18[a]
VSL (μm/s)	89.57 ± 1.59	90.27 ± 1.26	63.73 ± 1.61[b]	67.88 ± 0.95[a]
VCL (μm/s)	140.39 ± 3.22	141.62 ± 2.60	126.95 ± 2.16[b]	132.37 ± 2.14[a]
ALH (μm)	5.82 ± 0.15	6.17 ± 0.38	5.98 ± 0.13	5.84 ± 0.87
BCF (HZ)	28.46 ± 0.90	29.62 ± 0.67	24.29 ± 0.85	24.77 ± 1.18
STR (%)	87.35 ± 1.12	88.12 ± 1.06	86.72 ± 1.88	84.79 ± 1.19
LIN (%)	63.87 ± 0.84	64.07 ± 1.12	50.02 ± 0.98	51.30 ± 0 .74
AI (%)	74.63 ± 1.54	75.21 ± 1.03	58.23 ± 0.94[b]	62.06 ± 0.88[a]

Data are means ± SEM. For each factor, different superscripts within a column differ significantly ($p < 0.05$).
RM, transrectal massage; EE, electro-ejaculation; VAP, velocity average path; VSL, velocity according to the straight path; LIN, linearity index; ALH, amplitude of lateral head displacement; BCF, beat cross frequency; STR, straightness; LIN, linearity and AI, percentage of spermatozoa with intact acrosome; CASA, computer-assisted semen analysis.
Means values in the same rows by semen type with different superscripts are significantly different ($p < 0.05$).

(Sarsaifi et al., 2013)

SEMEN CRYOPRESERVATION

Successful semen cryopreservation is one of the important factors for the application of reproductive techniques such as artificial insemination and in vitro embryo production which contribute to upgrade and increase animal production. Currently, many research in semen cryopreservation continue to improve existing procedure in order to establish better quality semen after thawing. Research in determination of appropriate extender including cryoprotectants, concentration of antioxidants and their method of addition, cooling rates and freezing method are some of the research areas that being conducted not only in livestock but also in wildlife animals.

However, cryopreservation causes ultrastructural, biochemical, and functional damages on spermatozoa due to the temperature changes resulting in decreased motility and viability. In addition, causes of reduced sperm motility are related to seminal plasma enzymes. Therefore, seminal plasma plays an important role in sperm survival during cryopreservation process (Salamon and Ritar, 1982).

The deterioration and toxic effect of the seminal plasma were observed when goat's semen was diluted with egg yolk or milk extender. Nowadays, these extenders are widely used for the frozen storage of small ruminant semen (Salamon and Maxwell, 2000). The presence of enzymes in the seminal plasma caused the harmful interactions between seminal plasma and egg yolk or milk which decreases sperm motility and movement quality by disruption of cell membrane (Pellicer-Rubio and Combamous, 1998), resulting in a loss of motility, membrane integrity and consequently low fertility rate (Upreti *et al*., 1999).

Although removal of seminal plasma in small ruminant semen may be useful, several researchers however reported that this procedure may or may not have favourable effect on semen freezing

and thawing properties in goat semen (Kozdrowski *et al*., 2007; Peterson *et al*., 2007). Removal of seminal plasma is also a time consuming process that can damage the spermatozoa and need to be correctly performed. Therefore, previous research have used a variety of washing solutions and concentration regimes to find out the proper method for the improvement of cryopreserved semen quality. The centrifugation regimes and washing solutions used in buck semen cryopreservation varies from 400-2400 x g for 3-15 min with different washing solutions (Tuli and Holtz, 1994; Azeredo *et al*., 2001; Peterson *et al*., 2007; Kozdrowski *et al*., 2007; Sariozkan *et al*., 2010; Carvajal *et al*., 2004).

Due to limited studies on evaluating the effects of washing solutions and centrifugation regime on Boer goat semen, several experiments were carried out with the objectives to analyze the effects of seminal plasma removal using two different extenders, three different washing solutions and different centrifugation regimes on the characteristics of goat semen.

The results indicated that the practical and beneficial effects can be obtained by removing seminar plasma through centrifugation (3000 x g for 3 min) with Tris-based extender as washing solution in Boer goat semen cryopreservation protocol. However, these results are based only on motility characteristics, and therefore, further fertility trials are required as the ultimate test of improved cryopreservation (Soe Win Naing *et al*., 2011).

Effects of three different washing solutions on Boer goat semen characteristics

Before freezing	Progressive motility %	Intact acrosome %	Live spermatozoa %	Normal spermatozoa %
PBS	79.50 ± 1.17[a]	85.30 ± 1.32	78.70 ± 1.45[a]	93.40 ± 0.81
NS	76.50 ± 1.50[b]	84.20 ± 1.16	78.90 ± 1.27[b]	91.40 ± 0.60
TCG	84.50 ± 0.89[c]	87.50 ± 1.43	83.20 ± 1.45[c]	95.60 ± 0.58

After thawing	Total motility %	Forward motility %	Intact acrosome %	Live spermatozoa %	Normal spermatozoa %
PBS	54.50 ± 2.29[a]	47.50 ± 1.11[a]	67.70 ± 0.78[a]	61.40 ± 0.95[a]	88.70 ± 1.51
NS	51.50 ± 2.89[b]	44.50 ± 1.74[b]	66.10 ± 1.19[a]	59.60 ± 1.31[a]	87.90 ± 1.50
TCG	61.50 ± 2.24[c]	54.50 ± 0.89[c]	73.90 ± 0.66[b]	68.50 ± 0.86[b]	89.90 ± 0.89

Mean ± SEM within each column, means with different alphabetical superscripts (a,b,c) are significantly different at least as $P<0.05$ (ANOVA – Post hoc test). PBS = Phosphate Buffer Solution, NS = Normal Saline, TCG = Tris citric acid glucose extender

(Soe Win Naing *et al*., 2011)

The procedure of semen cryopreservation includes several necessary steps such as temperature reduction, cellular dehydration, freezing and thawing. If it is not properly handle, all these procedures inevitable produce cold shock and oxidative attack on the sperm membrane, which subsequently decreased spermatozoa survival and fertilizing ability leading to death and also imposed negative effects on the preservation of semen for artificial insemination. Cold shock affecting spermatozoa is partly associated with oxidative attack and the generation of reactive oxygen species. Excessive production of reactive oxygen species during semen cryopreservation has been associated with reduced spermatozoa post-thaw motility, viability, membrane and acrosome integrity, antioxidant status and fertility.

As indicated earlier that the seminal plasma of goat semen is packed with many antioxidant components, so its removal will make spermatozoa more vulnerable due to the low concentrations of natural antioxidants. Therefore, it is more imperative to restore the normal level of antioxidants in semen by adding them in extenders during the semen cryopreservation process. This process also overcomes the detrimental effects of reactive oxygen species (Donoghue and Donoghue, 1997). The molecules of the antioxidant could reduce the impact of oxidative stress and thus improve semen quality after thawing. There are a number of antioxidants used for this purpose in many livestock species such as butylated hydroxytoluene (BHT), a synthetic phenolic antioxidant. It is a synthetic analogue of vitamin E that checks the auto-oxidation reaction by converting peroxy radicals to hydroperoxides. Butylated hydroxytoluene has been tested successfully to preserve liquid semen and minimize cold shock damage in several livestock such as turkey (Donoghue and Donoghue, 1997) stallions (Ball *et al*., 2001), boars (Roca *et al*., 2004), bulls (Shoae and Zamiri, 2008) and buffaloes (Ijaz *et al*., 2009). In spite of these promising results, the

use of BHT in freezing extenders is not common and limited data is available with respect to its use in the goat semen cryopreservation.

Due to the limited data, further studies are required to obtain more information on the effectiveness of antioxidant capacity and to determine the most effective additives in the freezing of goat semen. Therefore a study was initiated to investigate the effect of various concentrations of BHT on sperm characteristics of Boer goat semen cryopreservation. The study also aims to identify the optimal concentration of BHT supplementation in Tris egg yolk based extender during cooling and freezing.

The results showed that addition of 2.0 mM butylated hydroxytoluene in Tris egg yolk based extender during cooling and freezing provide the optimal protection of Boer goat semen during cryopreservation (Memon *et al*., 2011).

Rate of motility, membrane integrity, morphology, acrosome integrity and viability of Boer goat spermatozoa before freezing at various concentrations of butylated hydroxytoulene (BHT)

BHT (mM)	Motility (%)	Membrane integrity (%)	Morphology (%)^{ns}	Acrosome integrity (%)	Viability (%)
0.0	64.40 ± 0.90^{a}	67.80 ± 0.53^{a}	85.20 ± 0.65	68.90 ± 0.64^{a}	76.60 ± 0.67^{a}
0.5	65.90 ± 0.53^{ab}	69.90 ± 0.53^{b}	85.10 ± 0.66	71.30 ± 0.83^{b}	78.50 ± 0.50^{ab}
1.0	69.80 ± 0.73^{c}	71.70 ± 0.42^{cd}	85.50 ± 0.52	73.40 ± 0.92^{b}	78.60 ± 0.85^{b}
2.0	69.90 ± 0.55^{c}	72.20 ± 0.47^{d}	85.80 ± 0.47	73.70 ± 0.87^{b}	78.40 ± 0.52^{ab}
3.0	66.70 ± 0.82^{b}	70.70 ± 0.52^{ac}	84.80 ± 0.63	72.40 ± 0.56^{b}	76.70 ± 0.54^{ab}
P-values	<.0001	<.0001	0.7908	0.0004	0.0476

Values with different superscripts within column differ significantly at $P < 0.05$; ^{ns} no significant difference.

(Memon *et al*., 2011)

Percentages of motility, membrane integrity, morphology, acrosome integrity and viability in post thaw Boer goat spermatozoa at various concentrations of butylated hydroxytoulene (BHT)

BHT (mM)	Motility (%)	Membrane integrity (%)	Morphology (%)	Acrosome integrity (%)	Viability (%)
0.0	57.10 ± 0.55^{a}	54.10 ± 0.95^{a}	80.30 ± 0.82^{a}	58.10 ± 0.60^{a}	69.70 ± 0.52^{a}
0.5	57.60 ± 0.72^{a}	58.20 ± 0.74^{b}	82.60 ± 0.54^{b}	57.90 ± 0.66^{a}	70.80 ± 0.51^{ab}
1.0	61.40 ± 0.69^{b}	59.90 ± 0.75^{b}	82.80 ± 0.73^{b}	61.10 ± 0.55^{ab}	71.60 ± 0.43^{b}
2.0	63.20 ± 0.53^{c}	59.40 ± 0.52^{b}	82.20 ± 0.66^{ab}	61.80 ± 0.53^{c}	71.70 ± 0.52^{b}
3.0	57.40 ± 0.56^{a}	55.40 ± 0.69^{a}	80.50 ± 0.48^{a}	60.00 ± 0.42^{b}	70.70 ± 0.42^{ab}
P-values	<.0001	<.0001	0.0191	<.0001	0.0356

Values with different superscripts within column differ significantly at $P < 0.05$.

(Memon *et al*., 2011)

The function of sugar in the extender for cryopreservation is to maintain the osmotic pressure of the diluents by inducing cell dehydration and less ice crystal formation into the spermatozoa. Apart from the function as energy source to support spermatozoa motility and movement, sugar has the ability to form a glass (vitrification) by depressing the membrane phase transition temperature of dry lipids. It also interacts with phospholipid membranes at low hydration and thus causes stabilization of the membranes (Aisen *et al*., 2002; Hincha *et al*., 2006).

Many researchers have studied the effect of sugar supplementation in semen extender on the quality of cryopreserved spermatozoa. Although glucose has been suggested to be more suitable sugar than fructose, lactose or raffinose in Tris-based media in ram semen (Salamon and Visser, 1972), but several reports indicated that there were no effect on post-thaw spermatozoa motility with different sugar addition (Abdelhakeam *et al*., 1991; Molinia *et al*., 1994). In contrast, trehalose, xylose and fructose significantly increased total active sperm rates compared to other sugars (glucose, sucrose, galactose, lactose, maltose and raffinose) in frozen thaw samples of dog spermatozoa (Yildiz *et al*., 2000). A more recent study indicated that monosaccharide, especially fructose enhanced the better effect on semen quality than disaccharides and trisaccharides in red deer epididymal sperm cryopreservation (Fernández-Santos *et al*., 2007).

Due to its remarkable stabilizing properties to protect protein and lipids membranes from degradation during the freeze-drying process, trehalose has been extensively used to improve spermatozoa quality in semen cryopreservation. Trehalose improved sperm membrane integrity, spermatozoa viability and post-thaw fertility in ram semen (Bucak and Tekin, 2007), mouse (Bayarad *et al*., 1998), dog (Yamashiro *et al*., 2007), and boar semen (Gutiérrez-Pérez *et al*., 2009). However, due to the paucity of information on its effect

on goat spermatozoa, several studies were conducted to determine the effect of two monosaccharide and two disaccharide sugars on sperm characteristics in Boer goat semen cryopreservation.

The results of these studies indicated that the combination of glucose (69.38mM) with trehalose (198.24 mM) minimizes cell damage and increases number of viable spermatozoa following cryopreservation of Boer goat semen (Naing *et al*., 2010).

Effect of sugar combination on semen characteristics of Boer goat pre-freezing and post-thawing

Pre-freezing	Progressive motility%	Intact acrosome%	Live spermatozoa%	Normal spermatozoa%
G	77.3 ± 2.2	87.3 ± 3.6	83.0 ± 1.5	92.4 ± 2.2
St	76.9 ± 2.1	89.2 ± 3.8	83.8 ± 2.1	93.1 ± 1.9
Ft	76.2 ± 1.6	87.2 ± 3.7	82.8 ± 1.7	93.4 ± 2.3
Gt	75.5 ± 1.9	88.8 ± 3.9	82.7 ± 1.6	93.0 ± 1.9

Post-thawing	Total motility%	Forward motility%	Acrosome integrity%	Membrane integrity%	Live spermatozoa%	Normal spermatozoa%
G	50.1 ± 2.1^{a}	29.1 ± 2.4^{a}	58.5 ± 3.2^{a}	53.7 ± 1.9^{a}	50.6 ± 4.0^{a}	84.7 ± 3.1
St	47.2 ± 2.6^{a}	32.4 ± 6.1^{a}	63.2 ± 2.0^{a}	51.4 ± 1.5^{a}	55.7 ± 2.4^{a}	85.0 ± 2.7
Ft	59.3 ± 1.7^{b}	43.2 ± 1.5^{b}	60.3 ± 2.4^{a}	62.8 ± 1.6^{b}	51.9 ± 2.8^{a}	83.6 ± 2.9
Gt	67.4 ± 1.4^{c}	54.2 ± 1.5^{c}	75.1 ± 3.5^{b}	69.2 ± 1.4^{c}	66.4 ± 2.3^{b}	83.2 ± 3.7

Mean ± SEM within each column, mean with different alphabetical superscripts are significantly different (ANOVA–post hoc test at $P < 0.05$). G = glucose (control), St = combination of sucrose and trehalose, Ft = combination of fructose and trehalose, and Gt = combination of glucose and trehalose.

(Naing *et al*., 2010)

Effect of different concentrations of trehalose on semen characteristics of Boer goat pre-freezing and post-thawing

Pre-freezing	Progressive motility%	Intact acrosome%	Live spermatozoa%	Normal spermatozoa%
T1	80.5 ± 1.6	85.7 ± 0.8	90.8 ± 0.5	94.5 ± 0.9
T2	78.5 ± 2.1	83.7 ± 0.8	90.8 ± 0.7	95.6 ± 0.6
T3	80.5 ± 1.7	84.5 ± 0.9	91.1 ± 0.7	95.4 ± 0.4
T4	81.5 ± 1.7	85.0 ± 0.8	91.6 ± 1.2	96.1 ± 0.3
T5	82.0 ± 1.7	86.3 ± 0.9	90.7 ± 0.7	94.4 ± 3.2

Post-thawing	Total motility%	Forward motility%	Acrosome integrity%	Membrane integrity%	Live spermatozoa%	Normal spermatozoa%
T1	50.6 ± 1.9^{a}	40.1 ± 2.1^{a}	62.9 ± 2.3^{a}	57.9 ± 2.2^{a}	56.9 ± 2.9^{a}	91.7 ± 1.5
T2	58.7 ± 2.5^{bc}	47.9 ± 1.9^{b}	67.6 ± 2.5^{ab}	64.6 ± 1.9^{b}	61.4 ± 3.6^{ab}	92.5 ± 1.4
T3	62.8 ± 1.7^{c}	52.6 ± 1.7^{b}	71.9 ± 3.2^{b}	68.8 ± 1.9^{bc}	65.2 ± 1.9^{b}	93.1 ± 1.6
T4	72.7 ± 1.2^{d}	64.2 ± 1.9^{c}	84.6 ± 2.2^{c}	72.4 ± 1.8^{c}	77.4 ± 1.2^{c}	93.4 ± 2.5
T5	52.7 ± 2.3^{ab}	40.5 ± 2.0^{a}	63.2 ± 1.1^{a}	57.6 ± 1.5^{a}	57.9 ± 2.3^{a}	91.1 ± 1.9

Mean ± SEM within each column, mean with different alphabetical superscripts are significantly different (ANOVA–post hoc test at $P < 0.05$). T1 = 33.04 mM trehalose, T2 = 49.59 mM trehalose, T3 = 66.08 mM trehalose, T4 = 198.24 mM trehalose, and T5 = 264.32 mM trehalose.

(Naing *et al.,* 2010)

Procedures related with cryopreservation produce cold shock and oxidative attack, which reduces the post-thaw quality of semen for artificial insemination (Bucak *et al.,* 2009). The plasma membrane of mammalian spermatozoa presents high concentrations of polyunsaturated fatty acids, which make it susceptible to free radicals induced peroxidative damage, especially following cryopreservation, with a subsequent loss of sperm functions (Lenzi *et al.,* 2002).

Supplementing cryopreservation media with antioxidants improved the quality of semen against free radicals-induced damage (Sariozkan *et al*., 2009; Memon *et al*., 2011). However, due to contradictory effect of antioxidant on spermatozoa freezing, an experiment was conducted to investigate the effect of different concentration of ascorbic acid supplementation on Boer goat semen cryopreservation.

The results concluded that chilled and post-thawed sperm quality (motility, membrane integrity, morphology, acrosome integrity and viability) of Boer goat improved when a Tris-based extender supplemented with 2.5–8.5 mg⁄mL ascorbic acid was used (Memon *et al*., 2013).

Mean + SEM of motility, membrane integrity, morphology, acrosome integrity and viability of Boer goat spermatozoa (a) before and (b) after freezing at various concentrations of ascorbic acid

Ascorbic acid, mg/ml	Motility (%)	Membrane integrity (%)	Morphology (%)	Acrosome integrity (%)	Viability (%)
(a)					
Control	59.42 ± 2.10^{c}	54.86 ± 1.45^{c}	73.85 ± 1.26^{b}	52.00 ± 1.13^{c}	68.43 ± 1.67^{c}
2.5	70.43 ± 1.36^{b}	63.15 ± 0.93^{b}	79.15 ± 0.76^{a}	64.29 ± 1.26^{b}	77.15 ± 1.20^{b}
4.5	71.43 ± 1.42^{b}	64.58 ± 0.94^{b}	81.43 ± 0.99^{a}	64.43 ± 1.17^{b}	79.85 ± 1.28^{ab}
6.5	72.58 ± 2.22^{ab}	68.15 ± 0.93^{a}	82.57 ± 2.45^{a}	65.15 ± 0.79^{b}	81.14 ± 1.51^{ab}
8.5	76.86 ± 1.42^{a}	70.00 ± 0.48^{a}	82.72 ± 0.91^{a}	70.85 ± 0.67^{a}	82.00 ± 1.0^{a}
(b)					
Control	43.58 ± 0.92^{d}	42.15 ± 0.63^{d}	72.15 ± 1.40^{b}	43.15 ± 1.48^{c}	66.29 ± 0.80^{c}
2.5	52.15 ± 0.94^{c}	49.85 ± 0.96^{c}	72.29 ± 1.06^{b}	52.00 ± 1.02^{b}	67.00 ± 1.02^{c}
4.5	57.85 ± 1.01^{b}	54.00 ± 0.97^{b}	72.58 ± 0.71^{b}	54.00 ± 1.17^{b}	68.15 ± 1.01^{bc}
6.5	65.00 ± 2.18^{a}	58.85 ± 1.05^{a}	75.58 ± 0.64^{b}	60.86 ± 1.22^{a}	70.00 ± 0.75^{b}
8.5	65.71 ± 1.70^{a}	59.43 ± 1.60^{a}	79.29 ± 1.74^{a}	63.29 ± 0.94^{a}	73.58 ± 1.04^{a}

Values with different superscripts within column differ significantly at $p < 0.05$.

(Memon *et al.*, 2013)

OOCYTE CRYOPRESERVATION

As stated earlier that cryopreservation is a challenging biotechnology tool where results are dependent on size of cells, stage of gamete development, and species of animal. Similar to spermatozoa, cryopreservation of oocytes and embryos also confronted with these variations. These variations are directly related to the biochemical and biophysical properties of oocytes and embryos at each stage and the type of species. Amongst all gametes and embryos, oocytes especially at the germinal vesicle stage are the most difficult to cryopreserve. Low viability after cryopreservation may be due to special characteristic features of oocytes (Kuwayama, 2007). The presence of dense cumulus cells, response to hypertonic cryopreservation solutions, presence or absence of channels in oolemma for turnover of each cryoprotectant agent (CPA), and physical changes of the zona pellucida due to exposure to CPAs are some of the factors that can hamper high cryosurvivability of immature oocytes. Until recently, few studies on cryopreservation of immature bovine oocytes have been reported. Although live birth of normal calves have been reported after freezing/thawing (Suzuki *et al*., 1996) and vitrification/warming of immature bovine oocytes (Vieira *et al*., 2002), the results were not satisfactory. However, due to its simplicity, inexpensive, and practicability, it is expected that vitrification will eventually replace the expensive and time-consuming conventional freezing.

Source of damages to oocytes during cryopreservation processes may derived from simple fundamentals of cryobiology such as equilibration temperature during handling of samples, cooling and warming rates, and different methods of vitrification. Equilibration temperature may directly affect the influx and efflux of CPAs through zona pellucida and oolemma of oocytes. This may results in either better protection or chemotoxicity to the oocyte. The

effects of higher rate of cooling and warming processes have been well acknowledged. The lower the cooling and warming rates, the higher is the possibility of ice crystal formation. Different types of cryodevices have been tested for vitrification of samples and some vitrification methods have been developed over the years ago. Each method is a combination of a cryodevice and CPAs mixture. The emergence of cryodevices resulting in high cooling and warming rates led to the possibility of decreasing the concentration of vitrification solution. Therefore, lower toxicity and higher viability rates encouraged researchers to follow the same method for oocytes at different developmental stages and species (Kuwayama *et al*., 2005; Zhou *et al*., 2010). However, very few reports have been published on the above mentioned matters for cryopreservation of immature bovine oocytes. Therefore, the effects of different equilibration temperatures (32º, 37º, and 41ºC) and cryodevices (open pulled straw, OPS; electron microscopy grid, EMG and cryotop) on viability of vitrified immature bovine oocytes were investigated.

The results indicated that oocytes equilibrated at 37°C had significantly higher maturation, cleavage, and blastocyst rates compared to that at 32ºC and 41ºC (Hajarian *et al*., 2010). The results also showed that the in vitro viability of vitrified immature bovine oocytes cryopreserved using cryotop device was higher than open-pulled straw and electron microscopy grid (Hajarian *et al*., 2011).

Polar body extrusion rate following in vitro maturation at different equilibration temperatures

Polar body rates	OPS (n = 49)	Cryotop (n = 58)	EMG (n = 77)	Control (n = 69)
Polar body +	10 (26%)^{c}	24 (41%)^{b}	24 (32%)^{c}	48 (70%)^{a}
Polar body -	27 (50%)^{a}	26 (45%)^{a}	39 (52%)^{a}	20 (29%)^{b}
Degenerated	12 (24%)^{a}	8 (14%)^{b}	14 (18%)^{ab}	1 (1%)^{c}

Data were pooled from 4 replicates; $^{a-c}$Values with different superscripts in the same row are significantly different; ($p<0.05$; ANOVA and Duncan's test)

(Hajarian *et al*., 2010)

In vitro viability of vitrified-warmed immature bovine oocytes equilibrated at different temperatures

Treatment	No. of oocytes	Viability (%)	Oocytes Cleaved (%)	≥8 cell embryos (%)	Blastocyst (%)
32°C	96	76.32±2.18^{ab}	30.84±0.58^{b}	13.05±4.21^{b}	3.65±1.18^{ab}
37°C	104	87.95±1.66^{a}	38.77±0.76^{a}	21.13±2.82^{a}	6.45±0.54^{a}
41°C	94	70.73±2.30^{b}	28.95±1.20^{b}	10.71±3.44^{b}	1.94±1.24^{b}

^{a}, ^{b}, ^{c}: Values in the same column with different superscripts differ significantly ($p<0.05$)

(Hajarian *et al*., 2010)

Polar body extrusion rate following in vitro maturation in different cryodevices

Polar body rates	OPS (n = 49)	Cryotop (n = 58)	EMG (n = 77)	Control (n = 69)
Polar body +	10 (26%)^{c}	24 (41%)^{b}	24 (32%)^{c}	48 (70%)^{a}
Polar body -	27 (50%)^{a}	26 (45%)^{a}	39 (52%)^{a}	20 (29%)^{b}
Degenerated	12 (24%)^{a}	8 (14%)^{b}	14 (18%)^{ab}	1 (1%)^{c}

Data were pooled from 4 replicates; $^{a-c}$Values with different superscripts in the same row are significantly different; ($p<0.05$; ANOVA and Duncan's test)

(Hajarian *et al*., 2011)

Nuclear maturation of vitrified immature bovine oocytes

Nuclear stage	OPS (n = 37)	Cryotop (n = 50)	EMG (n = 63)	Control (n = 68)
GV	15 (41%)[a]	8 (16%)[c]	16 (25%)[b]	4 (6.0%)[d]
GVBD-MI	6 (16%)[a]	10 (20%)[a]	13 (20%)[a]	2 (2.5%)[b]
MII	13 (35%)[d]	29 (58%)[b]	29 (46%)[c]	60 (88.0%)[a]
Unclassified	3 (7%)	3 (5%)	5 (7%)	2 (2.0%)

Data were pooled from 4 replicates; [a-d] Values with different superscripts in the same row are significantly different ($p<0.05$)

(Hajarian *et al*., 2011)

OESTRUS SYNCHRONIZATION

In the tropical countries, animal production is described as multipurpose, in which they are being used for milking, meat, clothing, fertilizer, fuel, draft power and as a form of currency. For cattle production, the main challenges causing decreased reproductive efficiency are associated with long calving interval and delayed first oestrus postpartum due to the high incidence of postpartum anestrus. The slow recovery of reproductive performance during postpartum is a limitation to the success of reproductive management programs. Therefore, synchronization and resynchronization of oestrus as well as artificial insemination could be used to increase reproductive performance and improve calving interval.

In Malaysia, ruminant production has recorded poor growth rates and presently the national requirements for beef, goat meat and mutton are largely met by imports. The Department of Veterinary Services statistical analysis reported that the consumption of beef has increased from 120,270 metric tonnes in 2001 to over 168,273 metric tonnes in 2011 with the increment of per capita consumption of 5.1 in 2001 to 5.71 in 2011 (DVS, 2013). With the increment of the demand, steps should be taken to propagate the number of

animals in order to reduce the loss in revenue through importation bills.

The main objective in animal production is to provide efficient and effective management systems. Maintaining good reproductive performance is part of these effective systems and it can be achieved by implementing proper reproductive biotechnologies. Some of the reproductive biotechnologies that can be used to increase reproductive efficiency include oestrus synchronization, artificial insemination and semen cryopreservation.

Synchronization of oestrus in cattle can facilitate the use of AI by reducing the time needed for the detection of oestrus compared to cattle entering oestrus spontaneously. It is also consider as an effective means of increasing the proportion of females that become pregnant early with shorter calving seasons and produce uniform calves. It was reported that up to 85% of cattle enter oestrus between 36 and 60 hour after being synchronized with progestin release subcutaneous implants or intravaginal progesterone releasing inserts (Diskin *et al*., 2002). It has also been reported that over 90% of cattle can be induced to come into oestrus within 24 hours (Cavalieri *et al.,* 2004).

Synchronization of oestrus in cattle not only allows one to predict the time of oestrus with reasonable accuracy but also helps the management in which a proper breeding programme may be planned and organized. Synchronization of oestrus also reduces the time required for detection of oestrus as well as facilitates for timed artificial insemination without detection of oestrus. Successful synchronization, followed by breeding will also improve pregnancy rates in beef cattle. To date, there are many methods of estrous synchronization; therefore, a study was conducted to determine the efficacy of estrous synchronization methods between intravaginal devices, i.e. controlled internal drug realizing device

(CIDR) versus progesterone releasing intravaginal device (PRID) in Kedah-Kelantan cows.

Results indicated that 18/24 (75.0%) cows showed standing heat following synchronization and majority of the cows that showed oestrus (11/18, 61.1%) were within 72 hours after removal of CIDR or PRID. Results also showed that cows treated with CIDR (91.7%; 11/12) had significantly better response to oestrus compared with PRID (58.3%; 7/12) (Wahid *et al*., 2001). In conclusion, CIDR is more efficient than PRID in terms of estrous synchronization in Kedah-Kelantan cows.

In order to attain a year round calving interval, management of estrous cycle in a herd of cows is very critical and this can be achieved by implementing oestrus synchronization (Cavalieri *et al*., 2008). However, resynchronization of oestrus and insemination in the non-pregnant cows after a first unsuccessful synchronization are utilized to reduce variations in inter-estrus interval. This procedure has been reported to improve and maintain reproductive efficiency (Eagles *et al*., 2001; Stevenson *et al*., 2003; McDougall and Loeffler, 2004). Furthermore, following the first synchronized oestrus and artificial insemination, cows can also be resynchronized for the subsequent second and third estrous cycles which subsequently helped to improve the reproductive performance of cows (Cavalieri *et al*., 2000; Cavalieri and Macmillan, 2002). A resynchronization protocol which involves placing an intra-vaginal device containing progesterone for 12-15 days after the first insemination for 7-8 days, combined with an intramuscular injection of 0.5-1.0 mg oestradiol benzoate at the time of intra-vaginal device insertion and another injection of equal dose within 24-48 h after intra-vaginal device removal was reported to enhance pregnancy rate (Cavalieri *et al*., 2000, 2004, 2008). These treatments consistently increased the synchrony of return to oestrus in non-pregnant cattle (Van Cleeff *et*

al., 1996; Stevenson *et al*., 2003). However in CIDR-treated cattle, the initial pregnancy rate (Chenault *et al*., 2003) or the pregnancy rate after resynchronization (Stevenson *et al*., 2003) was reduced. Prostaglandin F2 alpha (PGF2a) and its synthetic analogues have been used to control the estrous cycle in cattle (Wright and Malmo, 1992). Nevertheless, the effectiveness of PGF2alpha to synchronize oestrus is dependent upon the presence of a responsive corpus luteum. Calving interval of 13.7 and 13.5 months have been reported in the Canada (Lucy, 2001) and the Netherlands (Fatehi and Schaeffer, 2003), respectively. Slow resumption of reproductive cycle during the postpartum period remains a problem in cattle raised in tropical countries like Indonesia and Malaysia with the period to first postpartum oestrus reported to be about 4.5 months (Yimer *et al*., 2010).

Since many synchronization programmes have been used to facilitate oestrus detection rate in beef cattle but with varying degrees of success, therefore, a study was conducted to depict oestrus response and pregnancy rate of cows following synchronization and resynchronization with CIDR as well as between groups of cows resynchronized with CIDR and PGF2alpha. This study revealed a similar effect of both initial synchronization and re-synchronization with CIDR on Brangus cows in terms of the proportion of cows that exhibit oestrus (Malik et al., 2011). It also showed that both CIDR and PGF2a protocols for oestrus resynchronization in postpartum Brangus cows have indicated a similar proportion oestrus response and pregnancy rates.

Percentage of estrus response and pregnancy in synchronization and resynchronization using CIDR and PGF2a

Items	Total population	No. of cows mounting (%)	Cows of pregnant	Pregnancy (%) based on	
				Estrus response	Total sample
Initial (synchronization)	140	94/140 (67.1)	41	39/94 (41.4)	29.2
Resynchronization (CIDR)	49	40/49 (81.6)	15	15/40 (37.5)	30.6
Resynchronization ($PGF_2\alpha$)	50	35/50 (70.0)	14	11/35 (31.5)	28.0

Non significant between resynchronization using CIDR and $PGF_2\alpha$ methods

(Malik *et al.,* 2011)

IN VITRO PRODUCTION OF EMBRYOS

In vitro production of embryos provides opportunities in many areas such as cryopreservation of oocytes and embryos, embryo transfer and cloning. Currently, it is well known facts that pre-implantation embryos can be produced via totally in vitro procedures, i.e. in vitro maturation (IVM), in vitro fertilization (IVF) and in vitro culture (IVC) prior to transfer to the recipient. Due to its vast number of applications, these procedures provide almost endless research opportunities in the field of in vitro production of embryos. To date, it has been indicated that approximately 15% of bovine embryos are produced by in vitro embryo production (IVEP) throughout the world (Mapletoft and Hasler, 2005).

The importance of cumulus cells for in vitro fertilization of matured oocytes is still a controversy among researchers. It is believed that there are some beneficial roles of cumulus cells on in vitro fertilization leading to higher cleavage rate and higher yield of blastocysts. However, in some earlier studies, the presence of cumulus cells surrounding the oocyte is not necessary for a successful fertilization (Behalova and Greve, 1993), and some other researchers have observed that cumulus cells interfere with sperm penetration (Hawk *et al*., 1992). Therefore, a study was conducted to determine the effect of cumulus cells removal from

in vitro matured oocytes just before insemination on cleavage rate of bovine embryos. The result of the study suggests that intact-cumulus cells improved significantly the cleavage rate following in vitro fertilization of bovine oocytes, leading to higher cleavage rates (Sianturi *et al*., 2001). The presence of intact cumulus cells provide a capacitation-inducing mechanism and facilitate the interaction between spermatozoa and zona pellucida (Cox *et al*., 1993). It was also reported that the cumulus cells secrete heparin-like glycosaminoglycans which may render a supportive role in capacitation and fertilization and exert a specific effect on sperm motility and acrosome reaction (Ball *et al*., 1983).

Effect of cumulus cells removal on cleavage rate

Types of oocytes	Numbers of oocytes inseminated	Numbers of oocytes cleaved (%)
Cumulus-intact	361	257 (71.2)"
Denuded	224	107 (47.8)"

Data were pooled from 4 replicates

[a,b] Values with different superscripts in the same column are significantly different (P<0.01)

(Sianturi *et al*., 2001)

Most of the reported studies in vitrification of oocytes and/or embryos focus on basics of cryobiology such as increasing cooling/warming rates (Morato *et al*., 2008), vitrification solution ingredients (Yamada *et al*., 2007) and temperature of equilibration solution (Hajarian *et al*., 2010). Although, the previously studies resulted in more favorable results, still the trend of vitrification of immature bovine oocytes is not satisfactory enough. Besides the importance of cryobiological factors, developmental stage of

immature oocyte may play significant role not only for in vitro embryo production (IVEP) system but also for the vitrification outcome. Almost as a routine part of IVEP system activities, immature oocytes are selected based on morphology of oocyte and its surrounding cells (Hawk and Wall, 1994; Hazeleger *et al*., 1995). It has been shown that a portion of morphologically selected oocytes are still in growing phase and not yet ready for maturation step (Rodriguez-Gonzalez *et al*., 2002; Alm *et al*., 2005). The pool of immature oocytes can be separated effectively using brilliant cresyl blue (BCB) stain test (Rodriguez-Gonzalez *et al*., 2002; Manjunatha *et al*., 2007). The BCB test is non-invasive and measures glucose-6-phosphate dehydrogenase (G6PDH) activity. G6PDH is a protein synthesized in growing immature oocytes and converts BCB stain to colorless. Conversely, grown oocyte cytoplasm which has lower levels of G6PDH remains blue in color (BCB+) because there is no reduction for BCB to a colorless compound (Bhojwani *et al*., 2007; Ishizaki *et al*., 2009). Based on previous studies, capability of BCB+ oocytes to develop to the blastocyst stage is higher than BCB-oocytes (Alm *et al*., 2005; Manjunatha *et al*., 2007; Opiela *et al*., 2010) even after somatic cell nuclear transfer (Bhojwani *et al*., 2007). This competency of BCB+ oocytes has been demonstrated on molecular and subcellular level as well (Tomer *et al*., 2008). In addition, the BCB test also selected a significantly higher number of competent oocytes in heifers for in vitro embryo production (Pujol *et al*., 2004). Majority of the genes upregulated in BCB+ oocytes are related to cell cycle, transcription and protein biosynthesis regulation (Tomer *et al*., 2008). On top of that, BCB- oocytes had lower transcript level of genes involved in mitochondrial biosynthesis (Opiela *et al*., 2010). So far however, no research has been found that studied the consequence of selection of developmentally competent oocytes on cryopreservation results.

Therefore, a study was conducted with the objective to evaluate the BCB test before vitrification and therefore enhance the maturity rate after vitrification of immature bovine oocyte.

The results of the study indicated that selection of immature oocytes using BCB stain was effective and could be used before cryopreservation of immature oocytes to improve the in vitro fertilization rate (Hajarian Hadi *et al*., 2010).

Polar body (PB) extrusion rate of treatment groups after vitrification

Groups	N	PB+	PB-	Degenerated
Control	72	49.0 (36/72)^{a}	51.0 (36/72)^{c}	0^{c}
BCB+	71	23.9 (17/71)^{b}	68.67 (49/71)^{ab}	7.4 (5/71)^{b}
BCB-	68	17.5 (12/68)^{b}	60.5 (41/68)^{bc}	22.0 (15/68)^{a}
Vitrified-control	75	18.6 (14/75)^{b}	75.1 (56/75)^{a}	6.2 (5/75)^{bc}

Data were pooled from 6 replicates, $^{a-d}$ Values with different superscripts in the same column are significantly different ($p<0.05$)

(Hajarian Hadi *et al*., 2010)

Nuclear maturation rate of treatment groups after vitrification

Groups	N	Unclassified	GV	GVBD-MI	MII
Control	72	6.2 (4/72)	1.1 (1/72)^{c}	5.7 (4/72)^{c}	87.0 (63/72)^{a}
BCB+	66	7.6 (5/66)	19.8 (13/66)^{b}	21.1 (14/66)^{ab}	51.58 (34/66)^{b}
BCB-	53	8.6 (5/53)	46.6 (24/53)^{a}	17.0 (9/53)^{b}	27.9 (15/53)^{d}
Vitrified-control	70	7.1 (5/70)	28.4 (20/70)^{b}	21.4 (17/70)^{a}	40.3 (28/70)^{c}

Data were pooled from 6 replicates, $^{a-d}$Values with different superscripts in the same column are significantly different ($p<0.05$)

(Hajarian Hadi *et al*., 2010)

In recent years, in vitro embryo production (IVEP) systems have been acknowledged to increase the rate of transferable embryos in bovine (Galli *et al*., 2004; Spicer *et al*., 2007) and the final objective in IVEP is the production of transferable embryos and

birth of healthy offspring. To achieve these objectives, every steps in IVEP have to be efficient. Although pre-implantation embryos may develop after in vitro culture, obvious differences exist between their developmental rates compared to those developed in vivo. For instance, approximately 60-80% of in vivo matured bovine oocytes are competent to reach to the metaphase II stage while only 25-40% of in vitro matured oocytes reach to this stage (Blondin *et al*., 2002; Dieleman *et al*., 2002; Avery *et al*., 2003). Failure to fertilize and develop to the blastocyst stage following in vitro procedures may indicate the lack of vital factors in the in vitro media which normally are available in vivo. Therefore, it is necessary to modify the media and conditions to support higher percentage of embryo development in vitro.

Several factors such as, hormones, proteins and growth factors supplemented to the culture medium may have crucial roles on the outcome of IVEP. It has been shown that insulin plays a crucial role for growth of variety of cells in the in vitro culture. Insulin bind to cell surface receptor and has been demonstrated that it stimulates glucose and amino acid uptake and protein synthesis (Harvey and Kaye, 1990; Kane *et al*., 1997) of mouse embryos (Kaye and Harvey, 1995). Several studies have indicated that insulin increases the in vitro oocyte maturation and development of human (Dashtizad *et al*., 2003), mice (Demeestere *et al*., 2004) and porcine embryos (Lee *et al*., 2005). Insulin receptor has also been detected in all stages of bovine embryos (Makarevich and Markkula, 2002). However, the results of using insulin are controversial for in vitro bovine embryo production and need more investigation. Therefore, several experiments were designed to study the effect of different concentration of insulin on bovine IVEP.

The results demonstrated that insulin promotes in vitro bovine embryos production. Supplementation of 10 µg/mL insulin

in maturation medium, exerted beneficial effects on nuclear maturation, cleavage and subsequent bovine embryo development in vitro. Furthermore, addition of insulin (10 µg/mL) to the culture medium showed positive effect on bovine embryo development to morula stage and slightly enhanced hatchability of produced blastocysts (Dashtizad *et al*., 2010).

Effect of different concentration of insulin in IVM media on in vitro maturation of bovine oocytes and subsequent embryo development

Pre-freezing	Progressive motility%	Intact acrosome%	Live spermatozoa%	Normal spermatozoa%
T1	80.5 ± 1.6	85.7 ± 0.8	90.8 ± 0.5	94.5 ± 0.9
T2	78.5 ± 2.1	83.7 ± 0.8	90.8 ± 0.7	95.6 ± 0.6
T3	80.5 ± 1.7	84.5 ± 0.9	91.1 ± 0.7	95.4 ± 0.4
T4	81.5 ± 1.7	85.0 ± 0.8	91.6 ± 1.2	96.1 ± 0.3
T5	82.0 ± 1.7	86.3 ± 0.9	90.7 ± 0.7	94.4 ± 3.2

Post-thawing	Total motility%	Forward motility%	Acrosome integrity%	Membrane integrity%	Live spermatozoa%	Normal spermatozoa%
T1	50.6 ± 1.9^{a}	40.1 ± 2.1^{a}	62.9 ± 2.3^{a}	57.9 ± 2.2^{a}	56.9 ± 2.9^{a}	91.7 ± 1.5
T2	58.7 ± 2.5^{bc}	47.9 ± 1.9^{b}	67.6 ± 2.5^{ab}	64.6 ± 1.9^{b}	61.4 ± 3.6^{ab}	92.5 ± 1.4
T3	62.8 ± 1.7^{c}	52.6 ± 1.7^{b}	71.9 ± 3.2^{b}	68.8 ± 1.9^{bc}	65.2 ± 1.9^{b}	93.1 ± 1.6
T4	72.7 ± 1.2^{d}	64.2 ± 1.9^{c}	84.6 ± 2.2^{c}	72.4 ± 1.8^{c}	77.4 ± 1.2^{c}	93.4 ± 2.5
T5	52.7 ± 2.3^{ab}	40.5 ± 2.0^{a}	63.2 ± 1.1^{a}	57.6 ± 1.5^{a}	57.9 ± 2.3^{a}	91.1 ± 1.9

Mean ± SEM within each column, mean with different alphabetical superscripts are significantly different (ANOVA–post hoc test at $P < 0.05$). T1 = 33.04 mM trehalose, T2 = 49.59 mM trehalose, T3 = 66.08 mM trehalose, T4 = 198.24 mM trehalose, and T5 = 264.32 mM trehalose.

(Dashtizad *et al*., 2010)

Effect of insulin supplementation at different concentrations in IVC media on in vitro development of bovine embryo

Insulin concentration ($\mu g\ mL^{-1}$)	No. of cultured oocytes	Mean % of cleaved oocytes ± SEM (n)	Mean % of morula oocytes ± SEM (n)	Mean % of blastocyst ± SEM (n)	Mean % of hatched blastocyst ± SEM (n)
0 (Control)	213	78.86 ± 2.79^{cd} (168/213)	60.55 ± 2.56^{cd} (129/213)	38.99 ± 2.77^{a} (83/213)	12.23 ± 3.02^{ab} (26/213)
1	212	86.38 ± 2.98^{b} (183/212)	74.60 ± 3.25^{b} (158/212)	37.70 ± 2.07^{a} (80/212)	10.32 ± 3.06^{ab} (22/212)
10	201	90.58 ± 2.02^{a} (182/201)	79.66 ± 3.86^{a} (160/201)	35.89 ± 3.44^{ab} (72/201)	14.49 ± 3.72^{a} (29/201)
20	206	82.04 ± 3.70^{c} (169/206)	63.13 ± 3.25^{c} (130/206)	30.63 ± 3.87^{c} (63/206)	8.77 ± 2.75^{b} (18/206)
50	223	75.38 ± 3.12^{d} (168/223)	58.31 ± 3.50^{d} (130/223)	32.83 ± 3.22^{bc} (73/223)	10.44 ± 3.61^{ab} (22/223)

Data were pooled from 6 replicates. ^{a,b,c,d}: Values with different superscripts in the same column are significantly different ($p<0.05$; ANOVA and Duncan's test)

(Dashtizad et al., 2010)

PREGNANCY DETERMINATION

One of the most important aspect in livestock production is the ability to determine the pregnancy status of the animals post-breeding. The ability to determine pregnancy at the earliest time enables the management in planning for the subsequent activities such as separation from non-pregnant animals, improve feeding regime and preparing the animals for parturition. Early determination of pregnancy also allows the management to investigate and/or remove unproductive animals so that unnecessary feeding wastage can be reduced leading to more profit obtained per animal.

With the advancement of technology, it is now possible to determine pregnancy in livestock at the earliest possible after breeding. The use of ultrasound scanning technique, pregnancy can be determined in less than 1 month in most ruminant species. This technique is not only could be used in livestock but also in wildlife.

CONCLUSION

The use of assisted reproductive biotechnology and combined with improve management in animal production is definitely important and has been applied in many countries. These combination provide opportunities to increase animal production in order to meet the increasing demand of animal products.

As a take home message, several issues have been identified and could be exploited in order to improve the ruminant industry in Malaysia. They are:

- It is now possible to produce pre-implantation embryos via totally in vitro procedures, which are in vitro maturation, in vitro fertilization and in vitro culture.

- The vast biodiversity of wildlife in this country provides many opportunities and must be utilized to improve the livestock industry.
- Semen, oocytes and embryo cryopreservation techniques are available to support the process of conservation and propagation in animals.
- Molecular techniques are available to assist in determining the genetic quality of animal breed prior to the actual breeding.
- Advanced reproductive biotechnologies such as oestrus synchronization, artificial insemination and pregnancy detection should be used as part of management activities in livestock production particularly in the ruminant sector.

Our journey to achieve the self-sufficiency level in ruminant products in Malaysia is still far although many efforts are geared toward fulfilling the requirements. A concerted effort from government agencies especially Department of Veterinary Services, Malaysian Agriculture Research and Development Institute, universities as well as the private sectors especially the ruminant farmers will eventually produce more wholesome "Made in Malaysia" livestock products to meet the ever increasing demand from consumers.

SELECTED IMAGES OF ACTIVITIES

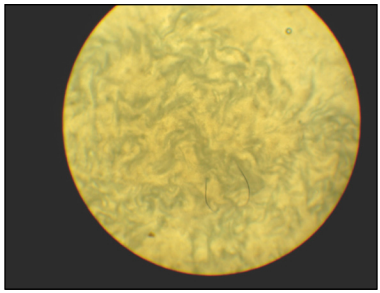

Figure 1 Semen wave pattern. X40

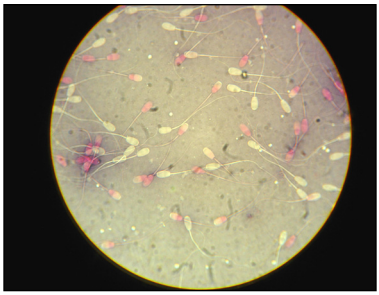

Figure 2 Stained spermatozoa X400

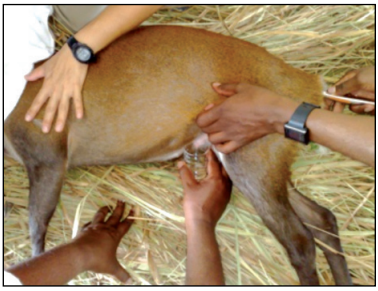

Figure 3 Semen collection in barking deer

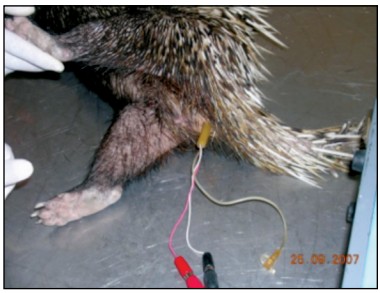

Figure 4 Semen collection in porcupines

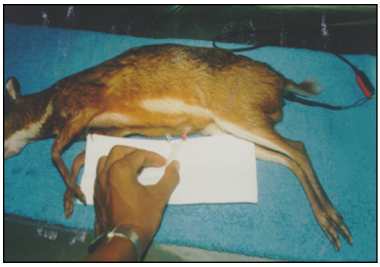

Figure 5 Semen collection in mouse deer

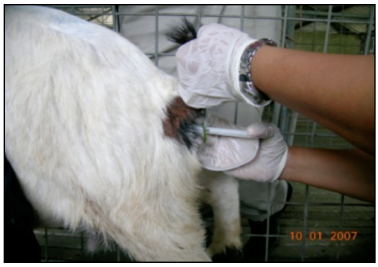

Figure 6 Estrus synchronization using CIDR in goats

Figure 7 Transcervical artificial insemination in goats

Figure 8 Laparoscopic artificial insemination in goats

Figure 9 Large animal surgery class

Figure 10 Artificial insemination training for veterinary officers

Figure 11 Embryo recovery and transfer in goats

Figure 12 Embryo collection and evaluation in goats

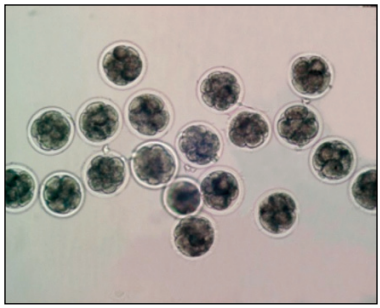

Figure 13 In vitro produced cattle embryos

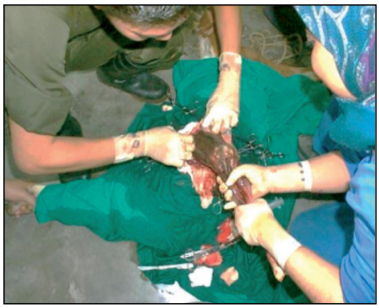

Figure 14 Caesarean section in a goat

Figure 15 Pregnancy diagnosis in goats

Figure 16 Pregnancy diagnosis in horses

Figure 17 Pregnancy diagnosis in barking deer

Figure 18 Pregnancy diagnosis in elephant

Figure 19 Pregnancy diagnosis in porcupines

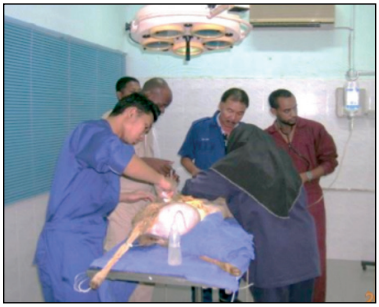

Figure 20 Ectopic pregnancy in sheep

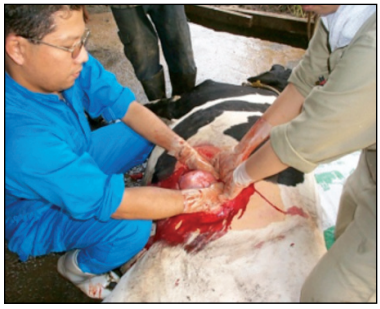

Figure 21 Caesarean section in a cow

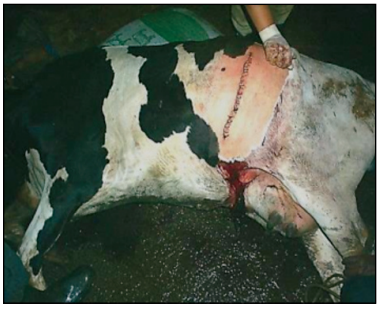

Figure 22 Caesarean section in a cow

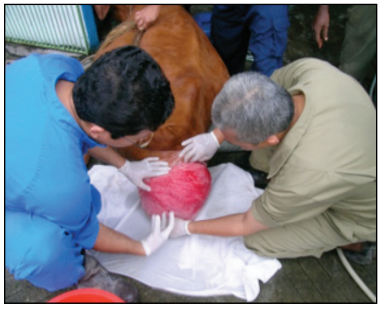

Figure 23 Uterine prolapsed in a cow

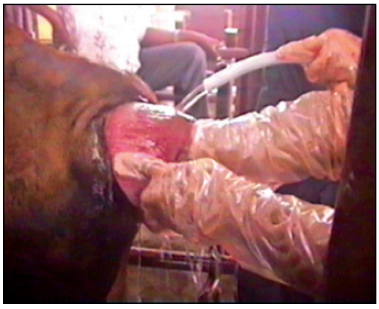

Figure 24 Uterine prolapsed in a cow

SELECTED PUBLICATIONS

Wahid, H., Yaakub, H., Ariff, O.M., Loh, T.C., Panandam, J.M. and Wan Khadijah, W.E. (2013). Livestock@2020: Uncertainties and Options. Proceedings of the 34th Malaysian Society of Animal Production Annual Conference, 3-5 June 2013, Kuantan, Pahang. Malaysian Society of Animal Production. 201 pages.

Yaakub, H., Alimon, A.R., Suhaimi, A.H.M.S., Engku Azahan, E.A., **Wahid, H.**, Panandam, J.M., Sumita, S., Musaddin, K. and Wan Khadijah, W.E. (2012). Malaysian Livestock Production: Calm Before The Storm. Proceedings of the 33rd Malaysian Society of Animal Production Annual Conference, 4-7 June 2012, Langkawi, Kedah. ISBN 978-983-43273-7-8. Malaysian Society of Animal Production. 211 pages.

Rasedee Abdullah, Mohamad Ariff Omar, tengku Azmi Tnegku Ibrahim, Saleha Abdul Aziz, Abdul Rani Bahaman and **Abdul Wahid Haron** (2010). Future Direction of Veterinary Education in Malaysia. ISBN 978-967-363-175-9. University Publication Centre. 96 pages.

Abd Wahid Haron and Rosnina Hj Yusoff (2009). Reproduksi dan Permanian Beradas Ternakan (*in Malay*). ISBN 978-967-344-075-7. Universiti Putra Malaysia Press. 77 pages.

Wahid, H., Rosnina, Y, Goh, Y.M., Musadin, K, Loh, T.C., Sabrina, S., Mohamed, W.Z., Azam Khan, M., Alimon, A.R. and Zainal Aznal, J. (2005). Revitalising the Animal Industry Towards Food Security: Proceedings of the 26th Malaysian Society of Animal Production Annual Conference, 1-3 June 2005, Primula Beach Resort, Terengganu. ISBN 983-3455-06-4. Universiti Putra Malaysia Press. 149 pages.

Wahid, H. and Rosnina, Y. (2011). Husbandry of Dairy Animals - Buffalo: Asia. In: Encyclopedia of Dairy Science (2nd Edition). Editor John W. Fuquay. Elsevier Ltd. pp. 772-779.

Wahid, H. (2005). Diagnosis Kebuntingan. In: Ensiklopedia Sains dan Teknologi: Jilid 8: Pertanian dan Perhutanan (1st Edition). Editors Ungku Haliza Ungku Zahar, Tn. Hj. Khalid Hj. Ahmad and Zakaria Abdullah. Selangor Darul Ehsan. Dawama Sdn. Bhd., pp. 78-80.

Wahid, H. (2005). Pemindahan Embrio. In: Ensiklopedia Sains dan Teknologi: Jilid 8: Pertanian dan Perhutanan (1st Edition). Editors Ungku Haliza Ungku Zahar, Tn. Hj. Khalid Hj. Ahmad and Zakaria Abdullah. Selangor Darul Ehsan. Dawama Sdn. Bhd., pp. 349-351.

Wahid, H. (2005). Permanian Beradas. In: Ensiklopedia Sains dan Teknologi: Jilid 8: Pertanian dan Perhutanan (1st Edition). Editors Ungku Haliza Ungku Zahar, Tn. Hj. Khalid Hj. Ahmad and Zakaria Abdullah. Selangor Darul Ehsan. Dawama Sdn. Bhd., pp. 408-409.

Jainudeen, M.R., **Wahid, H.** and Hafez, E.S.E. (2000). Chapter 12: Sheep and goats. In: Reproduction in Farm Animals. 7th. edition (Ed: B. Hafez and E.S.E. Hafez), Lippincott Williams & Wilkins (Baltimore), pp. 172-181.

Jainudeen, M.R., **Wahid, H.** and Hafez, E.S.E. (2000). Chapter 29: Ovulation induction, embryo production and transfer. In: Reproduction in Farm Animals. 7th. Edition (Ed: B. Hafez and E.S.E. Hafez.), Lippincott Williams & Wilkins (Baltimore), New York, pp. 405-430.

Azizah, A., **Wahid, H**., Ariff, O.M., Yaakub, H. and Ahmad, J. (2013). Determination of follicular wave development in oestrus synchronized beef cows. *Malaysian Journal of Animal Science*, 16(1): 53-66.

Memon, A.A., **H. Wahid**, Y. Rosnina, Y.M. Goh, M. Ebrahimi and F.M. Nadia (2013). Effect of ascorbic acid concentrations, methods of cooling and freezing on Boer goat semen cryopreservation. *Reproduction in Domestic Animals*, 48, 325–330.

Abdul Malik, **Abd Wahid Haron**, Rosnina Yusoff, Azhar Kasim and Sabri Mohd Yusoff (2012). Pregnancy rate following artificial insemination or natural service in postpartum estrus synchronized beef cattle. *Turkish Journal of Veterinary and Animal Sciences*, 36(4): 451-455.

Malik, **H. Wahid**, Y. Rosnina, A. Kasim and M. Sabri, (2012). Effects of timed artificial insemination following estrus synchronization in postpartum beef cattle. *Open Veterinary Journal*, 2: 1-5.

Akeel Ahmed Memon., **H. Wahid**, Y. Rosnina, Y.M. Goh, I. Mahdi, F.M. Nadia and G. Audrey (2011). Effect of hypotaurine and cysteine on sperm cytological parameters of cooled and post thaw Boer goat semen. *Elixir Bio Tech*, 38: 4100-4104.

Hajarian, H., **H. Wahid**, Y Rosnina, M. Daliri, M. Dashtizad, T. Mirzapour, N. Yimer, M.M. Bukar, M.I. Iswadi and O. Abas Mazni (2011). Cryotop device enhances vitrification outcome of immature bovine oocytes. *Journal of Animal and Veterinary Advances,* 10(19): 2541-2545.

Soe Win Naing, **Abd Wahid Haron**, Mohd Azam Khan Goriman, Rosnina Yusoff, Md Zuki Abu Bakar, Kazhal Sarsaifi, Muhammad Modu Bukar, Myint Thein, Than Kyaw and Maung Maung San (2011). Effect of seminal plasma removal, washing solutions and centrifugation regimes on Boer goat semen cryopreservation. *Pertanika Journal of Tropical Agricultural Science.* 34(2), 271-279.

Hajarian Hadi, **H. Wahid**, O. Abas Mazni, Y. Rosnina, M. Daliri and M. Dashtizad (2010). Effect of exposure to DMSO in vitrification solution on cytotoxicity and in vitro viability of immature bovine oocytes. *Reproductive BioMedicine Online* 20 Suppl. 3, S37-S40.

Dashtizad, M., **H. Wahid**, Y. Rosnina, M. Daliri, H. Hajarian and O. Abas Mazni (2010). Ghrelin improves the development of bovine preimplantation embryos *in vitro. Reproductive BioMedicine Online* 20 Suppl. 3, S60-S61.

Naing, S.W., **H. Wahid**, K. Mohd Azam, Y. Rosnina, A.B. Zuki, S. Kazhal, M. M. Bukar, M. Thein, T. Kyaw and M. M. San (2010). Effect of sugars on characteristics of Boer goat semen after cryopreservation. *Animal Reproduction Science*. 122, 23-28.

Hajarian, H., **H., Wahid**, O.A., Mazni, Y., Rosnina and M., Daliri (2010). Effect of equilibration temperature on in vitro viability and subsequent embryo development of vitrified-warmed immature bovine oocytes. Am. J. Anim. Vet Sci., 5: 71-75.

Haron, A.W., Yong Ming and Zainal, Z. Z. (2000). Electroejaculation, semen collection and evaluation in captive lesser Malay chevrotain (*Tragulus javanicus*). *Journal of Zoo and Wildlife Medicine*, 31(2), 164-167.

REFERENCES

Abdelhakeam, A.A., Graham, E.F., Vazquez, I.A., & Chaloner, K.M. (1991). Studies on the absence of glycerol in unfrozen and frozen ram semen: development of an extender for freezing: effects of osmotic pressure, egg yolk levels, type of sugars, and the method of dilution. *Cryobiology*, *28*(1), 43–49.

Aisen, E.G., Medina, V.H., & Venturino, A. (2002). Cryopreservation and post-thawed fertility of ram semen frozen in different trehalose concentrations. *Theriogenology*,*57*, 1088–1801.

Alm, H., H. Tomer, B. Lhrke, T. Viergutz & I.M. Ghoneim. (2005). Bovine blastocyst development rate in vitro is influenced by selection of oocytes by brilliant cresyl blue staining before IVM as indicator for glucose-6-phosphate dehydrogenase activity. *Theriogenology*, *63*, 2194-2205.

Avery, B., L. Strobech, T. Jacobsen, I. Bogh & T. Greve, (2003). In vitro maturation of bovine cumulus-oocyte complexes in undiluted follicular fluid: Effect on nuclear maturation, pronucleus formation and embryo development. *Theriogenology*, *59*, 987-999.

Azeredo, GA, Esper, C.R.,, & Resende, K.T. (2001). Evaluation of plasma membrane integrity of frozen-thawed goat spermatozoa with or without seminal plasma. *Small Ruminant Research*, *41*(3), 257-263.

Ball, B.A., Medina, V., Gravance, C.G., & Baumber, J. (2001). Effect of antioxidants on preservation of motility, viability and acrosomal integrity of equine spermatozoa during storage at 5^0C. T*heriogenology*, *56*, 577–589.

Ball, G.D., Leibfried, M.L., Lenz, R.W., Ax, R.L., Bavister, B.D., & First, N.L.(1983). Factors affecting successfully in vitro fertilization of bovine follicular oocytes. *Biol. Reprod*., *28*, 717-725.

Bayarad, T.S., Esther, E.N., & Kathleen, A.T. (1998). Comparison of glycerol, other polyols, trehalose, and raffinose to provide a defined cryoprotectant medium for mouse sperm cryopreservation. *Cryobiology*, *37*, 46–58.

Behalova, E., & Greve, T. (1993). Penetration rate of cumulus-enclosed versus denuded bovine eggs fertilized in vitro. *Theriogenology*, *39*, 186.

Bhojwani, S., H. Ahn, H. Tomer, W. Kanitz & R. Poehland, 2007. Selection of developmentally competent oocytes through brilliant cresyl blue stain enhances blastocyst development rate after bovine nuclear transfer. *Theriogenology*, *67*,341-345.

Blondin, P., D. Bousquet, H.N.G. Twagiramungu, F. Barnes & M.A. Sirard. (2002). Manipulation of follicular development to produce developmentally competent bovine oocytes. *Biol, Reprod*., *66*: 38-43.

Bucak, M.N., & Tekin, N. (2007). Protective effect of taurine, glutathione and trehalose on the liquid storage of ram semen. *Small Ruminant Res., 73*(1–3), 103–108.

Bucak, M.N., Tuncer, P.B., Sariozkan, S., & Ulutas, P.A. (2009). Comparison of the effects of glutamine and an amino acid solution on post-thawed ram sperm parameters, lipid peroxidation and antioxidant activities. *Small Ruminant Res., 81*, 13–17.

Carvajal, G., Cuello, C., Ruiz, M., Vazquez, J.M., Martinez, E.A., & Roca, J. (2004). Effect of centrifugation on Boar sperm. *Journal of Andrology*, *25*, 389-396.

Cavalieri, J. and K.L., & Macmillan. (2002). Synchronisation of oestrus and reproductive performance of dairy cows following administration of oestradiol benzoate or gonadotrophin releasing hormone during a synchronised pro-oestrus. *Aust. Vet. J*., *80*, 486-493.

Cavalieri, J., G. Hepworth, & L.A. Fitzpatrick. (2004). Comparison of two estrus synchronization and resynchronization treatments in lactating dairy cows. *Theriogenology*, *62*, 729-747.

Cavalieri, J., V.E. Eagles, M. Ryan & K.L. Macmillan. (2000). Patterns of onset of oestrus and reproductive performance of dairy cows enrolled in controlled breeding programs. *Proceedings of the Australian and New Zealand Combined Dairy Veterinarians Conference*, May 15-19, Vanuatu, pp: 161-182.

Cavalieri, J., V.M. Smart, G. Hepworth, M. Ryan & K.L. Macmillan. (2008). Ovarian follicular development and hormone concentrations in inseminated dairy cows with resynchronized estrous cycles. *Theriogenology*, *70*, 946-955.

Chenault, J.R., J.F. Boucher, KJ. Dame, J.A. Meyer & S.L. Wood-Follis. (2003). Intravaginal progesterone insert to synchronize return to estrus of previously inseminated dairy cows. *J. Dairy Sci*., *86*, 2039-2049.

Cox, I.F., Hormazabal, J., & Santa Maria, A. (1993). Effect of Cumulus on in vitro fertilization of bovine matured oocytes. *Theriogenology*, *40*, 1259-1267.

Dashtizad, M., A. Saremi & M. Azarnia, (2003). In vitro maturation and fertilization of human oocytes from unstimulated polycystic ovaries. *J. Reprod. Infertil*., *4*, 192-202.

Dashtizad, M., H. Wahid, Y. Rosnina, M. Daliri, Hajarian Hadi, Mehdi Najari, K.C. Yap & O. Abas Mazni. (2010). Synergistic Effect of Insulin on in vitro Development of Immature Bovine Oocytes. *American Journal of Animal and Veterinary Sciences*, *5*(4), 258-265.

Demeestere, I., C. Gervy, J. Centner, F. Devreker and Y. Englert. (2004). Effect of insulin-like growth factor-i during preantral follicular culture on steroidogenesis, in vitro oocyte maturation and embryo development in mice. *Biol. Reprod., 70*, 1664-1669.

Department of Veterinary Services Malaysia, 2013. http://www.dvs.gov.my/statistik;jsessionid=16E46839F0E25E65CD3AA5B85CBBC25D. Assessed on 17 October 2013.

Dieleman, S.J., P.J.M. Hendriksen, D. Viuff, P.D. Thomsen & P. Hyttel, 2002. Effects of in vivo prematuration and in vivo final maturation on developmental capacity and quality of preimplantation embryos. *Theriogenology*, *57*, 5-20.

Diskin, M.G., E.J. Austin & J.F. Roche, (2002). Exogenous hormonal manipulation of ovarian activity in cattle. *Domestic Animal Endocrinology*, *23*, 211–228.

Donoghue, A.M., & Donoghue, D.J. (1997). Effects of water- and lipid-soluble antioxidants on turkey sperm viability, membrane integrity, and motility during liquid storage. *Poultry Sci*., *76*, 1440–1445.

Eagles, V.E., J. Malmo & K.L. Macmillan. (2001). Resynchronising returns-to-service in anoestrous cows in Victorian dairy herds. *Proc. N. Zealand Soc. Anim. Prod*., *61*, 176-179.

Evans, G., Maxwell & W.M.C. (1987). In: Salamon's Artificial Insemination of Sheep and Goat Maxwell, W.M.C. (Ed.), Butterworths, Sydney.

Fatehi, J., & L.R. Schaeffer. (2003). Data management for the fertility project. Report to the Technical Committee of the Canadian Genetic Evaluation Board. Department of Animal and Poultry Science, University of Guelph, Canada, pp: 1-15. http://cgil.uoguelph.ca/dcbgc/Agenda03 03/FatehiReport.pdf

Fernández-Santos, M.R., Martínez-Pastor, F., García-Macías, V., Esteso, M.C., Soler, A.J., & de Paz, P. (2007). Extender osmolality and sugar supplementation exert a complex effect on the cryopreservation of Iberian red deer (*Cervus elaphushispanicus*) epididymal spermatozoa. *Theriogenology*, *67*(4), 738–753.

Galli, C., R. Duchi, G. Crotti, P. Turini, N. Ponderato, S. Colleoni, I. Lagutina, & G. Lazzari, 2004. Production and quality of bovine oocytes and embryos. *Vet. Res. Communication*, *28*, 121-126.

Gutiérrez-Pérez, O., Juárez-Mosqueda, M.D.L., Carvajal, S.U., & Ortega, M.E.T. (2009). Boar spermatozoa cryopreservation in low glycerol / trehalose enriched freezing media improves cellular integrity. *Cryobiology*, *58*(3), 287–292.

Hajarian, H., H., Wahid, O.A., Mazni, Y., Rosnina & M., Daliri. (2010). Effect of equilibration temperature on in vitro viability and subsequent embryo development of vitrified-warmed immature bovine oocytes. *Am. J. Anim. Vet Sci*., *5*, 71-75.

Hajarian Hadi, H. Wahid, Y Rosnina, M. Daliri, M. Dashtizad, H. Karamishabankareh, A Faizah, M.I. Iswadi & O. Abas Mazni. (2010). Selection of immature bovine oocytes using brilliant cresyl blue enhances nuclear maturity after vitrification. *Journal of Animal and Veterinary Advances*, *9*(21), 2710-2713.

Hajarian, H., H. Wahid, Y Rosnina, M. Daliri, M. Dashtizad, T. Mirzapour, N. Yimer, M.M. Bukar, M.I. Iswadi & O. Abas Mazni. (2011). Cryotop device enhances vitrification outcome of immature bovine oocytes. *Journal of Animal and Veterinary Advances*, *10*(19), 2541-2545.

Haron, A.W., Yong Ming, & Zainal, Z. Z. (2000). Electroejaculation, semen collection and evaluation in captive lesser Malay chevrotain (*Tragulus javanicus*). *Journal of Zoo and Wildlife Medicine*, *31*(2), 164-167.

Harvey, M.B., & P.L. Kaye. (1990). Insulin increases the cell number of the inner cell mass and stimulates morphological development of mouse blastocysts in vitro. *Development, 110*, 963-967.

Hawk, H.W., & R.J. Wall. (1994). Improved yields of bovine blastocysts from in vitro-produced oocytes. 1. Selection of oocytes and zygotes. *Theriogenology*, *41*, 1571-1583.

Hawk, H.W., Nell, N.D., Waterman, R.A., & Wall, R.J. (1992). Investigation of means to improve rates of fertilization in in vitro matured and in vitro fertilized bovine oocytes. *Theriogenology*, *38*, 989-998.

Hazeleger, N.L., DJ. Hill, R.B. Stubbings & J.S. Walton. (1995). Relationship of morphology and follicular fluid environment of bovine oocytes to their developmental potential in vitro. *Theriogenology*, *43*, 509-522.

Hincha, D.K., Popova, A.V., & Cacela, C. (2006). Effects of sugars on the stability and structure of Lipid membranes during drying. In: Advances in Planar Lipid Bilayers and Liposomes Leitmannova, A. (Ed.). Academic Press, pp. 127–189.

Ijaz, A., Hussain, A., Aleem, M., Yousaf, M.S., & Rehman, H. (2009). Butylated hydroxytoluene inclusion in semen extender improves the post-thawed semen quality of Nili-Ravi buffalo (*Bubalus bubalis*). *Theriogenology*, *71*, 1326–1329.

Ishizaki, G, H Watanabe, MMU Bhuiyan & Y Fukui. (2009). Developmental competence of porcine oocytes selected by brilliant cresyl blue and matured individually in a chemically defined culture media. *Theriogenology*, *72*, 72-80.

Kane, M., P. Morgan & C. Coonan. (1997). Peptide growth factors and preimplantation development. *Hum. Reprod. Update 3*, 137.

Kaye, P., & M. Harvey. (1995). The role of growth factors in preimplantation development. *Prog. Growth Factor Res*., *6*, 1-24.

Kozdrowski, R., Dubiel, A., Bielas, W., Dzieciol, M. (2007). Two protocols of cryopreservation of goat semen with the use of computer-analysis system. *Acta Veterinaria Brono*, *76*, 601-604.

Kuwayama, M., Vajta, G.B., Leda, S. and Kato, O. (2005). Comparison of open and closed methods for vitrification of human embryos and the elimination of potential contamination. *Reproductive Biomedicine Online*, *11*, 608-614.

Kuwayama, M., (2007). Oocyte cryopreservation. *Journal of Mammalian Ova Research*, *24*, 2-7.

Leboeuf, B., Restall, B., & Salamon, S. (2000). Production and storage of goat semen for artificial insemination. *Animal Reproduction Science*, *62*(1-3), 113-141.

Lee, M., S. Kang, B. Lee, & W. Hwang. (2005). The beneficial effects of insulin and metformin on in vitro developmental potential of porcine oocytes and embryos. *Biol. Reprod*., *73*, 1264.

Lenzi A., Gandini L., Lombardo F., Picardo M., Maresca V., & Panfili E. (2002). Polyunsaturated fatty acids of germ cell membranes, glutathione and glutathione dependent enzyme- PHGPx: from basic to clinic. *Contraception*, *65*, 301–304.

Lucy, M.C. (2001). Reproductive loss in high-producing dairy cattle: Where will it end? *J. Dairy Sci*., *84,* 1277-1293.

Makarevich, A., & M. Markkula (2002). Apoptosis and cell proliferation potential of bovine embryos stimulated with insulin-like growth factor I during in vitro maturation and culture. *Biol. Reprod*., *66*, 386.

Malik, A. Wahid, Y. Rosnina, M. Bukar, Yimer, A. Kasim & M. Sabri. (2011). Effects of Resynchronization with Progesterone and Prostaglandin F2 alpha on Estrus Response and Pregnancy Rate in Beef Cattle. *Journal of Animal and Veterinary Advances*, *10*(18), 2474-478.

Manjunatha, B.M., P.S.P. Gupta, M. Devaraj, J.P. Ravindra & S. Nandi, (2007). Selection of developmentally competent buffalo oocytes by brilliant cresyl blue staining before IVM. *Theriogenology*, *68*, 1299-1304.

Mapletoft, R., Hasler, J. (2005). Assisted reproductive technologies in cattle: a review. *Review of Science Technology*, *24*, 393-403.

McDougall, S., & S.H. Loeffler. (2004). Resynchrony of postpartum dairy cows previously treated for anestrus. *Theriogenology*, *61*, 239-253.

Memon A.A., Wahid, H., Rosnina, Y., Goh, Y.M., Ebrahimi, M., Nadia, F.M., & Audrey, G. (2011). Effect of butylated hydroxytoluene on cryopreservation of Boer goat semen in Tris egg yolk extender. *Anim Reprod Sci*., *129*, 44–49.

Memon, A.A., H. Wahid, Y. Rosnina, Y.M. Goh, M. Ebrahimi & F.M. Nadia. (2013). Effect of ascorbic acid concentrations, methods of cooling and freezing on Boer goat semen cryopreservation. *Reproduction in Domestic Animals*, *48*, 325–330.

Molinia, F.C., Evans, G., Quintana Casares, P.I., & Maxwell, W.M.C. (1994). Effect of monosaccharides and disaccharides in Tris-based diluents on motility, acrosome integrity and fertility of pellet frozen ram spermatozoa. *Anim. Reprod. Sc*i., *36*(1–2), 113–122.

Morato, R, D. Izquierdo, M.T. Paramio & T. Mogas, 2008. Cryotops versus Open-Pulled Straws (OPS) as carriers for the cryopreservation of bovine oocytes: Effects on spindle and chromosome configuration and embryo development. *Cryobiology*, *57*, 137-141.

Naing, S.W., H. Wahid, K. Mohd Azam, Y. Rosnina, A.B. Zuki, S. Kazhal, M. M. Bukar, M. Thein, T. Kyaw & M.M. San. (2010). Effect of sugars on characteristics of Boer goat semen after cryopreservation. *Animal Reproduction Science*,*122*, 23-28.

Opiela, J., D. Lipinski, R Slomski & L. Katska-Ksiazkiewicz, (2010). Transcript expression of mitochondria related genes is correlated with bovine oocyte selection by BCB test. *Anim*. *Reprod. Sci*., *118*, 188-193.

Pellicer-Rubio, M.T., & Combarnous, Y. (1998). Deterioration of goat spermatozoa in skimmed milk-based extenders as a result of oleic acid released by the bulbourethral lipase BUSgp60. *Journal of Reproduction and Fertility*, *2*, 95-105.

Peterson, K., Kappen, M.A.P.M., Ursem, P.J.F., Nothling, J.O., Colenbrander, B., & Gadella, B.M. (2007). Microscopic and flow cytometric semen assessment of Dutch AI-bucks: Effect of semen processing procedures and their correlation to fertility. *Theriogenology*, *67*(4), 863-871.

Prasetyaningtyas, W.E., S. Agungpriyono, Y. Yamamoto, A.H. Wahid, M. A. Setiadi & M. Fahrudin. (2006). Morphological and lectin histochemical studies of the spermatozoa of the lesser mouse deer (*Tragulus javanicus*). *Jurnal Veterinar Malaysia*, *18*(2), 11 -15.

Pujol, M., M. Lopez-Bejar & M.T. Paramio. (2004). Developmental competence of heifer oocytes selected using the Brilliant Cresyl Blue (BCB) test. *Theriogenology*, *61*, 735-744.

Roca, J., Gil, M.A., Hernaˇındez, M., Parrilla, I., Vazquez, J.M., & Martinez, E.A. (2004). Survival and fertility of boar spermatozoa after freeze thawing in extender supplemented with butylated hydroxytoluene. *J. Androl*., *25*, 397–405.

Rodriguez-Gonzalez, E., M. Lopez-Bejar, E. Velilla & M.T. Paramio. (2002). Selection of prepubertal goat oocytes usmg the brilliant cresyl blue test. *Theriogenology*, *57*, 1397-1409.

Salamon, S., & Maxwell, W.M.C. (2000). Storage of ram semen. *Animal Reproduction Science*, *62*, 77-111.

Salamon, S., & Ritar, A.J. (1982). Deep freezing of Angora goat semen: Effects of diluent composition and method and rate of dilution on survival of spermatozoa. *Austrian Journal of Biological Sciences*, *35*, 295-303.

Salamon, S., & Visser, D. (1972). Effect of composition of Tris-based diluents and thawing solution on survival of ram spermatozoa frozen by the pellet method. *Austrian Journal of Biological Sciences*, *25*, 605.

Salisbury, G.W., & Van Demark, N.L. (1985). Physiology of Reproduction and Artificial Insemination of Cattle. Yogyakarta: Gadjah Mada University Press. pp. 314-343.

Sariozkan S., Bucak M.N., Tuncer P.B., Ulutas P.A., & Bilgen A. (2009). The influence of cysteine and taurine on microscopic-oxidative stress parameters and fertilizing ability of bull semen fallowing cryopreservation. *Cryobiology*, *58*, 134–138.

Sariozkan, S., Bucak, M.N., Tuncer, P.B., Tasdemir, V., Kinet, H., & Vlutas, P.A. (2010). Effects of different extenders and centrifugation/washing on post thaw microscopic-oxidative stress parameters and fertilizing ability of Angora buck sperm. *Theriogenology*, *73*, 316-323.

Sarsaifi, K., Y. Rosnina, M.O. Ariff, H. Wahid, H. Hani, N. Yimer, J. Vejayan, S. Win Naing & M.O. Abas. (2013). Effect of Semen Collection Methods on the Quality of Pre- and Post-thawed Bali Cattle (*Bos javanicus*) Spermatozoa. *Reproduction in Domestic Animals*, 1-7.

Shoae, A., & Zamiri, M.J. (2008). Effect of butylated hydroxytoluene on bull spermatozoa frozen in egg yolk-citrate extender. *Anim. Reprod. Sci*. *104*, 414–418.

Sianturi, R.S.G., M. Thein, K.C. Yap, A.D. Bakar, H. Wahid & Y. Rosnina. (2001). The importance of cumulus cells for in vitro fertilization of bovine oocytes. *2nd International Congress/ 13th Vet. Association Malaysia Congress and CVA-Australasia/Oceania Regional Symposium*, Kuala Lumpur, pp. 135-136.

Soe Win Naing, Abd Wahid Haron, Mohd Azam Khan Goriman, Rosnina Yusoff, Md Zuki Abu Bakar, Kazhal Sarsaifi, Muhammad Modu Bukar, Myint Thein, Than Kyaw and Maung Maung San. (2011). Effect of seminal plasma removal, washing solutions and centrifugation regimes on Boer goat semen cryopreservation. *Pertanika Journal of Tropical Agricultural Science*, *34*(2), 271-279.

Spicer, L.J., B.A. Buchanan, L.T. Chapin & H.A. Tucker. (2007). Effect of exposure to various durations of light on serum insulin-like growth factor-i in prepubertal Holstein heifers. *Am. J. Anim. Vet. Sci*., *2*, 42-45.

Stevenson, I.S., I.A. Cartmill, B.A. Hensley & S.Z. El Zarkouny, (2003). Conception rates of dairy cows following early not-pregnant diagnosis by ultrasonography and subsequent treatments with shortened Ovsynch protocol. *Theriogenology*, *60*, 475-483.

Sundararaman, M.N., & Edwin, M.J. (2008). Changes in motility characteristics of goat spermatozoa during glycerol- equilibration and the relevance to cryopreservation. *Asian Journal of Cell Biology*, *3*, 22-33.

Suzuki, T., Boediono, A., Takagi, M., Saha, S., & Sumantri, C. (1996). Fertilization and development of frozen-thawed germinal vesicle bovine oocytes by a one-step dilution method in vitro. *Cryobiology*, *33*, 515-524.

Tomer, H, N. Ghanem, G Ambros, M. HIker & W. Tomek, (2008). Molecular and subcellular characterisation of oocytes screened for their developmental competence based on glucose-6-phosphate dehydrogenase activity. *Reproduction*, *135*, 197-212.

Tuli, R.K., & Holtz, W.(1994). Effect of glycerolization procedure and removal of seminal plasma on post-thaw survival and got-release from Boer goat spermatozoa. *Theriogenology*, *42*(3), 547-555.

Upreti, G.C., Hall, E.L., Koppens, D., Oliver, J.E., & Vishwanath, R.. (1999). Studies on the measurement of phospholipaseA2 (PL A2) and PL A2 inhibitor activities in ram semen. *Animal Reproduction Science*, *56*, 107-121.

Van Cleeff, J., K.L. Macmillan, M. Drost, M.C. Lucy & W.W. Thatcher. (1996). Effects of administering progesterone at selected intervals after insemination of synchronized heifers on pregnancy rates and resynchronization of returns to service. *Theriogenology*, *46*, 1117-1130.

Vieira, A.D., Mezzalira, A., Barbieri, D.P., Lehmkuhl, R.C., Rubin, M.I.B., & Vajta, G. (2002). Calves born after open pulled straw vitrification of immature bovine oocytes. *Cryobiology*, *45*, 91-94.

Wahid. H., C.S. Khor, O. Abas Mazni, M. Thein, R.S.G., Sianturi, A.M. Padzil, K.C. Yap & A.D. Bakar. (2001). Effect of intravaginal devices on estrous synchronization in Kedah-Kelantan cows. *2nd International Congress/ 13th Vet. Association Malaysia Congress and CVA-Australasia/Oceania Regional Symposium*, Kuala Lumpur, pp. 153-155.

Wright, P.J., & J. Malmo.(1992). Pharmacological manipulation of fertility. *Vet. Clin. North Am. Food Anim. Pract*., *8*, 57-89.

Yamada, G, H.VA. Caetano, R. Simoes, A.G Nicacio & W.B. Feitosa. (2007). Immature bovine oocyte cryopreservation: Comparison of different associations with ethylene glycol, glycerol and dimethylsulfoxide. *Anim. Reprod. Sci*., *99*, 384-388.

Yamashiro, H., Narita, K., Sugimura, S., Han, Y.J., Sugawara, A., Morohaku, K., Nakazato, F., Konno, T., Yoshida, M., & Sato, E.(2007). Trehalose enhanced the freezability of Poodle dog sperm collected by an artificial vagina. *Animal Reproduction Science*, *102*(1-2), 165-171.

Yildiz, C., Kaya, A., Aksoy, M., & Tekeli, T. (2000). Influence of sugar supplementation of the extender on motility, viability and acrosomal integrity of dog spermatozoa during freezing. *Theriogenology*, *54*, 579–585.

Yimer, N., Y. Rosnina, H. Wahid, A.A. Saharee, K.C. Yap, & P. Ganesamurthi. (2010). Ovarian activity in beef and dairy cows with prolonged postpartum period and heifers that fail to conceive. *Trop. Anim. Health Prod*., *42*, 607-615.

Zhou, X.L., Al Naib, A., Sun, D.W., & Lonergan, P. (2010). Bovine oocyte vitrification using the Cryotop method: Effect of cumulus cells and vitrification protocol on survival and subsequent development. *Cryobiology*, *61*, 66-72.

BIOGRAPHY

Born on May 17, 1963 in Batu Pahat, Johor, I enrolled in primary school from 1971-1976 and later continued at the secondary school from 1977-1982. From 1983 to 1988, I pursued my study for the degree of Doctor of Veterinary Medicine at Universiti Putra Malaysia. After working as a research assistant for about a year, I was offered a tutorship. From 1991-1993, I pursue my study in PhD in Animal Reproduction at the University College Dublin, Republic of Ireland under the supervision of eminent professor, Prof. Ian Gordon. During my 3-year study there, I have published 18 scientific papers in local as well as international journals and proceedings.

In 1993, I was appointed as a lecturer at the Faculty of Veterinary Medicine, Universiti Putra Malaysia. I was awarded with several research grants such as short-term and Intensification of Research in Priority Area (IRPA) projects, focusing on the use of assisted reproductive technologies in domestic ruminants.

In the beginning of this millennium, I was appointed as a member of the Asian Rhino Specialist Group, in collaboration with the International Rhino Foundation (IRF) and the Department of Wildlife and National Parks Malaysia (PERHILITAN), to specially stimulate the effort in breeding Sumatran Rhinoceros in captivity. This research was initiate to pilot a research in establishing an enzyme immunoassay technique for rhino fecal progesterone metabolite as well as improve captive rhino breeding.

Since I joined this Faculty, I have attended more than 50 courses or workshops, either as organizing committee member, invited speaker and participant. Apart from publishing papers in journals and proceedings, I am also a co-author of two chapters in the well-known textbook "Reproduction in Farm Animals - 7th. Edition" catering for mainly undergraduate students in reproductive biology,

veterinary medicine, and animal sciences. I have contributed many veterinary topics in Bahasa Malaysia for the *Ensiklopedia Sains dan Teknologi* (Science and Technology Encyclopaedia).

In April 1999, I was involved in the preparation for MS ISO 9001 certification as one of the steering committee. As a result of that, in 2000, Faculty of Veterinary Medicine, Universiti Putra Malaysia was awarded the certification covering a comprehensive eight core businesses. This achievement is the first faculty among Malaysia's public universities to achieve such award.

In 2000, I was awarded an Outstanding Excellence Service Award by Universiti Putra Malaysia. Subsequently, I was promoted to an Associate Professor in July 2001 and on 1st February 2002, I was appointed as Head, Department of Veterinary Clinical Studies, Faculty of Veterinary Medicine UPM. Subsequently, on 1st July 2003, I was appointed as Deputy Dean of Academic and Student Affairs of the faculty.

On 29th October 2007, I was appointed as Deputy Dean in charge on the University Veterinary Hospital (UVH) of the faculty. I was appointed as Animal Biotechnology Consultant to ar-Raudhah Bio-Tech Farm Sdn Bhd, a BioNexus status company dealing with small ruminant management and biotechnology activities. In 2007, together with Innovation and Commercialization Centre, UPM, I manage to establish a spin-off company, Putra Al-Mawashi Genetics Sdn Bhd (PALM-Gen). The company successfully secured RM500,000 grant under Malaysian Technology Development Corporation (MTDC) focusing on commercialization of cattle frozen semen and services.

In 2010, I was the main author of the book "Reproduksi dan Permanian beradas Ternakan" published by UPM Press. This book focused on basic information on livestock reproduction and artificial insemination. It was targeted to not only those in the secondary

school diploma level but also farmer who are interested to seek in depth on animal reproduction.

On 1st January 2012, I was appointed as the Director of Taman Pertanian Universiti (TPU) (University Agriculture Park), one of the service provider centers in UPM providing and maintaining facilities not only in teaching and research but also looking at the opportunities for income generation of the university.

To date, I have supervised 19 PhD and 13 Masters students either as main or co-supervisor. I have also published more than 120 publications in the form of books, chapter in books, research articles in journals and proceedings as well as presented my research achievements in national and international conferences.

These output and achievements have provided me with input, energy, enthusiasm and commitment to continue doing greater career opportunities especially in teaching, research and post-graduate supervision. It also serves as a platform for a greater and more challenging leadership responsibility in the future.

ACKNOWLEDGEMENTS

I would like to take this opportunity to thank many people whom may be contributed alongside my journey and sharing the achievement and success.

First and foremost I would like to thank Allah subhanahu wa ta'ala, the most merciful and the most compassionate for the opportunity given to me in occupying His great universe and without Him I will definitely cannot be here.

To my late wonderful parents Haron bin Hj Mustapha and Mindek bt Mohd Kari for nurturing and providing me with their love and support. To my brothers and sisters, Mohd Sawal, Rokiah, Kalthom, Ahmad and late brother Esa for their awesome spirit of togetherness and love.

To the government of Malaysia for supporting me not only throughout my study period but also research grants.

To Universiti Putra Malaysia management for giving me the opportunity to pursue my study and continue to support me in the teaching, research and professional services since 1983 till now.

To all my mentors, teachers, lecturers, colleagues and friends from the government agencies and private sectors including farmers for allowing me to be part of your life and helping me throughout my journey as a student, a lecturer, a clinician and a colleague.

To all my undergraduate and postgraduate students who are willing to share their knowledge and experience as well as for being able to withstand the challenges in seeking of knowledge until graduation. They are from different country and background. To those who appointed me as the main supervisor, Siti Romlah Jais (Brunei), Roslaini Hj. Rusli (Malaysia), Kiron Deep Singh Kanwal (India), Riasari Gail Sianturi (Indonesia), Khor Chun Siah (Malaysia), Myint Thein (Myanmar), Mohamed Ali Attia (Jordan), Nasser Saleh Obad (Yemen), Hadi Hajarian (Iran), Amare Eshetu

Gemeda (Ethiopia), Mojtaba Dashtizad (Iran), Kajal Sar Saifi (Iran), Soe Win Naing (Myanmar), Azizah Amri (Malaysia), Abdul Malik (Indonesia), Akeel Ahmed Memon (Pakistan), Mohamad Shuib Mohamad Mohtar (Malaysia), Zaid KH. Mahmood (Iraq), Asmatullah Kaka (Pakistan) and and Mohamad Fazel (Iran).

To those who appointed me as the co-supervisor, Alawattage Don Nimal Chandrasiri (Sri Lanka), Samsul Bariah Sharudin (Malaysia), Choong Siew Shean (Malaysia), Intan Shameha Abdul Razak (Malaysia), Koo Li Lia (Malaysia), Tooba Mirzapour (Iran), Nurhusien Yimer Degu (Ethiopia), Sriyanto (Indonesia), Huda Yahia Hamid Fadl Alla (Sudan), Muhammad Modu Bukar (Nigeria), Shahram Jafari (Iran), Khumran Armiya'u Mada (Nigeria), Fazhana Ismail (Malaysia), and Abdul Hamid KH Al Sharif (Iran).

To those who completed their final year project and selected me as their supervisor or co-supervisor, Tang Su Ling, Vijayndra a/l Madawan, Kok Tien Sang, Ong Boo Ping, Yong Ming, Azizah Amri, Wong Phooi Sun, Azlan @ Tompang Enjah, Liong Siew Ling, Robert Paulis, Noraisah Marsan, Thulasi a/p Kathrasan, Lim Wee Meng, Wong Chooi Thing, Song Fook Min, Sabtina Adinah Abu Bakar, Anusha a/p Vijayan, Ahmad Nazri Abdul Rahman, Mohd Khair Ahmad, Zaidi Suif, Mark Hiew Wen Han, Zamri Zainir, Ahmad Fikri Ahmad Yunus, Nesa wathi a/p Subramaniam, Nor Aini bt Warzukni, Lee Sook Yeng, Siti Sumaiyah Mohd Yusof, Juwairiyah Hj Jali, Netasha A/P Nagarajan and Nezzy Suzie Nelson.

Finally, but most importantly, I wish to give my heartfelt thanks to my beloved family especially to my wife Ernie Amin for her unconditional love, continuous support and faith in me and to my wonderful children, Amir Faliq, Nurfatihah and Nurwahidah for their love and inspiration throughout my journey...

LIST OF INAUGURAL LECTURES

1. Prof. Dr. Sulaiman M. Yassin
   The Challenge to Communication Research in Extension
   22 July 1989

2. Prof. Ir. Abang Abdullah Abang Ali
   Indigenous Materials and Technology for Low Cost Housing
   30 August 1990

3. Prof. Dr. Abdul Rahman Abdul Razak
   Plant Parasitic Nematodes, Lesser Known Pests of Agricultural Crops
   30 January 1993

4. Prof. Dr. Mohamed Suleiman
   Numerical Solution of Ordinary Differential Equations: A Historical Perspective
   11 December 1993

5. Prof. Dr. Mohd. Ariff Hussein
   Changing Roles of Agricultural Economics
   5 March 1994

6. Prof. Dr. Mohd. Ismail Ahmad
   Marketing Management: Prospects and Challenges for Agriculture
   6 April 1994

7. Prof. Dr. Mohamed Mahyuddin Mohd. Dahan
   The Changing Demand for Livestock Products
   20 April 1994

8. Prof. Dr. Ruth Kiew
   Plant Taxonomy, Biodiversity and Conservation
   11 May 1994

9. Prof. Ir. Dr. Mohd. Zohadie Bardaie
   Engineering Technological Developments Propelling Agriculture into the 21st Century
   28 May 1994

10. Prof. Dr. Shamsuddin Jusop
    Rock, Mineral and Soil
    18 June 1994

11. Prof. Dr. Abdul Salam Abdullah
Natural Toxicants Affecting Animal Health and Production
29 June 1994

12. Prof. Dr. Mohd. Yusof Hussein
Pest Control: A Challenge in Applied Ecology
9 July 1994

13. Prof. Dr. Kapt. Mohd. Ibrahim Haji Mohamed
Managing Challenges in Fisheries Development through Science and Technology
23 July 1994

14. Prof. Dr. Hj. Amat Juhari Moain
Sejarah Keagungan Bahasa Melayu
6 Ogos 1994

15. Prof. Dr. Law Ah Theem
Oil Pollution in the Malaysian Seas
24 September 1994

16. Prof. Dr. Md. Nordin Hj. Lajis
Fine Chemicals from Biological Resources: The Wealth from Nature
21 January 1995

17. Prof. Dr. Sheikh Omar Abdul Rahman
Health, Disease and Death in Creatures Great and Small
25 February 1995

18. Prof. Dr. Mohamed Shariff Mohamed Din
Fish Health: An Odyssey through the Asia - Pacific Region
25 March 1995

19. Prof. Dr. Tengku Azmi Tengku Ibrahim
Chromosome Distribution and Production Performance of Water Buffaloes
6 May 1995

20. Prof. Dr. Abdul Hamid Mahmood
Bahasa Melayu sebagai Bahasa Ilmu- Cabaran dan Harapan
10 Jun 1995

21. Prof. Dr. Rahim Md. Sail
Extension Education for Industrialising Malaysia: Trends, Priorities and Emerging Issues
22 July 1995

22. Prof. Dr. Nik Muhammad Nik Abd. Majid
The Diminishing Tropical Rain Forest: Causes, Symptoms and Cure
19 August 1995

23. Prof. Dr. Ang Kok Jee
The Evolution of an Environmentally Friendly Hatchery Technology for Udang Galah, the King of Freshwater Prawns and a Glimpse into the Future of Aquaculture in the 21st Century
14 October 1995

24. Prof. Dr. Sharifuddin Haji Abdul Hamid
Management of Highly Weathered Acid Soils for Sustainable Crop Production
28 October 1995

25. Prof. Dr. Yu Swee Yean
Fish Processing and Preservation: Recent Advances and Future Directions
9 December 1995

26. Prof. Dr. Rosli Mohamad
Pesticide Usage: Concern and Options
10 February 1996

27. Prof. Dr. Mohamed Ismail Abdul Karim
Microbial Fermentation and Utilization of Agricultural Bioresources and Wastes in Malaysia
2 March 1996

28. Prof. Dr. Wan Sulaiman Wan Harun
Soil Physics: From Glass Beads to Precision Agriculture
16 March 1996

29. Prof. Dr. Abdul Aziz Abdul Rahman
Sustained Growth and Sustainable Development: Is there a Trade-Off 1 or Malaysia
13 April 1996

30. Prof. Dr. Chew Tek Ann
Sharecropping in Perfectly Competitive Markets: A Contradiction in Terms
27 April 1996

31. Prof. Dr. Mohd. Yusuf Sulaiman
Back to the Future with the Sun
18 May 1996

32. Prof. Dr. Abu Bakar Salleh
Enzyme Technology: The Basis for Biotechnological Development
8 June 1996

33. Prof. Dr. Kamel Ariffin Mohd. Atan
The Fascinating Numbers
29 June 1996

34. Prof. Dr. Ho Yin Wan
Fungi: Friends or Foes
27 July 1996

35. Prof. Dr. Tan Soon Guan
Genetic Diversity of Some Southeast Asian Animals: Of Buffaloes and Goats and Fishes Too
10 August 1996

36. Prof. Dr. Nazaruddin Mohd. Jali
Will Rural Sociology Remain Relevant in the 21st Century?
21 September 1996

37. Prof. Dr. Abdul Rani Bahaman
Leptospirosis-A Model for Epidemiology, Diagnosis and Control of Infectious Diseases
16 November 1996

38. Prof. Dr. Marziah Mahmood
Plant Biotechnology - Strategies for Commercialization
21 December 1996

39. Prof. Dr. Ishak Hj. Omar
Market Relationships in the Malaysian Fish Trade: Theory and Application
22 March 1997

40. Prof. Dr. Suhaila Mohamad
Food and Its Healing Power
12 April 1997

41. Prof. Dr. Malay Raj Mukerjee
A Distributed Collaborative Environment for Distance Learning Applications
17 June 1998

42. Prof. Dr. Wong Kai Choo
Advancing the Fruit Industry in Malaysia: A Need to Shift Research Emphasis
15 May 1999

43. Prof. Dr. Aini Ideris
Avian Respiratory and Immunosuppressive Diseases- A Fatal Attraction
10 July 1999

44. Prof. Dr. Sariah Meon
Biological Control of Plant Pathogens: Harnessing the Richness of Microbial Diversity
14 August 1999

45. Prof. Dr. Azizah Hashim
The Endomycorrhiza: A Futile Investment?
23 Oktober 1999

46. Prof. Dr. Noraini Abdul Samad
Molecular Plant Virology: The Way Forward
2 February 2000

47. Prof. Dr. Muhamad Awang
Do We Have Enough Clean Air to Breathe?
7 April 2000

48. Prof. Dr. Lee Chnoong Kheng
Green Environment, Clean Power
24 June 2000

49. Prof. Dr. Mohd. Ghazali Mohayidin
Managing Change in the Agriculture Sector: The Need for Innovative Educational Initiatives
12 January 2002

50. Prof. Dr. Fatimah Mohd. Arshad
Analisis Pemasaran Pertanian di Malaysia: Keperluan Agenda Pembaharuan
26 Januari 2002

51. Prof. Dr. Nik Mustapha R. Abdullah
Fisheries Co-Management: An Institutional Innovation Towards Sustainable Fisheries Industry
28 February 2002

52. Prof. Dr. Gulam Rusul Rahmat Ali
Food Safety: Perspectives and Challenges
23 March 2002

53. Prof. Dr. Zaharah A. Rahman
Nutrient Management Strategies for Sustainable Crop Production in Acid Soils: The Role of Research Using Isotopes
13 April 2002

54. Prof. Dr. Maisom Abdullah
Productivity Driven Growth: Problems & Possibilities
27 April 2002

55. Prof. Dr. Wan Omar Abdullah
Immunodiagnosis and Vaccination for Brugian Filariasis: Direct Rewards from Research Investments
6 June 2002

56. Prof. Dr. Syed Tajuddin Syed Hassan
Agro-ento Bioinformation: Towards the Edge of Reality
22 June 2002

57. Prof. Dr. Dahlan Ismail
Sustainability of Tropical Animal-Agricultural Production Systems: Integration of Dynamic Complex Systems
27 June 2002

58. Prof. Dr. Ahmad Zubaidi Baharumshah
The Economics of Exchange Rates in the East Asian Countries
26 October 2002

59. Prof. Dr. Shaik Md. Noor Alam S.M. Hussain
Contractual Justice in Asean: A Comparative View of Coercion
31 October 2002

60. Prof. Dr. Wan Md. Zin Wan Yunus
Chemical Modification of Polymers: Current and Future Routes for Synthesizing New Polymeric Compounds
9 November 2002

61. Prof. Dr. Annuar Md. Nassir
Is the KLSE Efficient? Efficient Market Hypothesis vs Behavioural Finance
23 November 2002

62. Prof. Ir. Dr. Radin Umar Radin Sohadi
Road Safety Interventions in Malaysia: How Effective Are They?
21 February 2003

63. Prof. Dr. Shamsher Mohamad
The New Shares Market: Regulatory Intervention, Forecast Errors and Challenges
26 April 2003

64. Prof. Dr. Han Chun Kwong
Blueprint for Transformation or Business as Usual? A Structurational Perspective of the Knowledge-Based Economy in Malaysia
31 May 2003

65. Prof. Dr. Mawardi Rahmani
Chemical Diversity of Malaysian Flora: Potential Source of Rich Therapeutic Chemicals
26 July 2003

66. Prof. Dr. Fatimah Md. Yusoff
An Ecological Approach: A Viable Option for Aquaculture Industry in Malaysia
9 August 2003

67. Prof. Dr. Mohamed Ali Rajion
The Essential Fatty Acids-Revisited
23 August 2003

68. Prof. Dr. Azhar Md. Zain
Psychotheraphy for Rural Malays - Does it Work?
13 September 2003

69. Prof. Dr. Mohd. Zamri Saad
Respiratory Tract Infection: Establishment and Control
27 September 2003

70. Prof. Dr. Jinap Selamat
Cocoa-Wonders for Chocolate Lovers
14 February 2004

71. Prof. Dr. Abdul Halim Shaari
High Temperature Superconductivity: Puzzle & Promises
13 March 2004

72. Prof. Dr. Yaakob Che Man
Oils and Fats Analysis - Recent Advances and Future Prospects
27 March 2004

73. Prof. Dr. Kaida Khalid
Microwave Aquametry: A Growing Technology
24 April 2004

74. Prof. Dr. Hasanah Mohd. Ghazali
Tapping the Power of Enzymes- Greening the Food Industry
11 May 2004

75. Prof. Dr. Yusof Ibrahim
The Spider Mite Saga: Quest for Biorational Management Strategies
22 May 2004

76. Prof. Datin Dr. Sharifah Md. Nor
The Education of At-Risk Children: The Challenges Ahead
26 June 2004

77. Prof. Dr. Ir. Wan Ishak Wan Ismail
Agricultural Robot: A New Technology Development for Agro-Based Industry
14 August 2004

78. Prof. Dr. Ahmad Said Sajap
Insect Diseases: Resources for Biopesticide Development
28 August 2004

79. Prof. Dr. Aminah Ahmad
The Interface of Work and Family Roles: A Quest for Balanced Lives
11 March 2005

80. Prof. Dr. Abdul Razak Alimon
Challenges in Feeding Livestock: From Wastes to Feed
23 April 2005

81. Prof. Dr. Haji Azimi Hj. Hamzah
Helping Malaysian Youth Move Forward: Unleashing the Prime Enablers
29 April 2005

82. Prof. Dr. Rasedee Abdullah
In Search of An Early Indicator of Kidney Disease
27 May 2005

83. Prof. Dr. Zulkifli Hj. Shamsuddin
Smart Partnership: Plant-Rhizobacteria Associations
17 June 2005

84. Prof. Dr. Mohd Khanif Yusop
From the Soil to the Table
1 July 2005

85. Prof. Dr. Annuar Kassim
Materials Science and Technology: Past, Present and the Future
8 July 2005

86. Prof. Dr. Othman Mohamed
Enhancing Career Development Counselling and the Beauty of Career Games
12 August 2005

87. Prof. Ir. Dr. Mohd Amin Mohd Soom
Engineering Agricultural Water Management Towards Precision Framing
26 August 2005

88. Prof. Dr. Mohd Arif Syed
Bioremediation-A Hope Yet for the Environment?
9 September 2005

89. Prof. Dr. Abdul Hamid Abdul Rashid
The Wonder of Our Neuromotor System and the Technological Challenges They Pose
23 December 2005

90. Prof. Dr. Norhani Abdullah
Rumen Microbes and Some of Their Biotechnological Applications
27 January 2006

91. Prof. Dr. Abdul Aziz Saharee
Haemorrhagic Septicaemia in Cattle and Buffaloes: Are We Ready for Freedom?
24 February 2006

92. Prof. Dr. Kamariah Abu Bakar
Activating Teachers' Knowledge and Lifelong Journey in Their Professional Development
3 March 2006

93. Prof. Dr. Borhanuddin Mohd. Ali
Internet Unwired
24 March 2006

94. Prof. Dr. Sundararajan Thilagar
Development and Innovation in the Fracture Management of Animals
31 March 2006

95. Prof. Dr. Zainal Aznam Md. Jelan
Strategic Feeding for a Sustainable Ruminant Farming
19 May 2006

96. Prof. Dr. Mahiran Basri
Green Organic Chemistry: Enzyme at Work
14 July 2006

97. Prof. Dr. Malik Hj. Abu Hassan
Towards Large Scale Unconstrained Optimization
20 April 2007

98. Prof. Dr. Khalid Abdul Rahim
Trade and Sustainable Development: Lessons from Malaysia's Experience
22 Jun 2007

99. Prof. Dr. Mad Nasir Shamsudin
Econometric Modelling for Agricultural Policy Analysis and Forecasting: Between Theory and Reality
13 July 2007

100. Prof. Dr. Zainal Abidin Mohamed
Managing Change - The Fads and The Realities: A Look at Process Reengineering, Knowledge Management and Blue Ocean Strategy
9 November 2007

101. Prof. Ir. Dr. Mohamed Daud
Expert Systems for Environmental Impacts and Ecotourism Assessments
23 November 2007

102. Prof. Dr. Saleha Abdul Aziz
Pathogens and Residues; How Safe is Our Meat?
30 November 2007

103. Prof. Dr. Jayum A. Jawan
Hubungan Sesama Manusia
7 Disember 2007

104. Prof. Dr. Zakariah Abdul Rashid
Planning for Equal Income Distribution in Malaysia: A General Equilibrium Approach
28 December 2007

105. Prof. Datin Paduka Dr. Khatijah Yusoff
Newcastle Disease virus: A Journey from Poultry to Cancer
11 January 2008

106. Prof. Dr. Dzulkefly Kuang Abdullah
Palm Oil: Still the Best Choice
1 February 2008

107. Prof. Dr. Elias Saion
Probing the Microscopic Worlds by Lonizing Radiation
22 February 2008

108. Prof. Dr. Mohd Ali Hassan
Waste-to-Wealth Through Biotechnology: For Profit, People and Planet
28 March 2008

109. Prof. Dr. Mohd Maarof H. A. Moksin
Metrology at Nanoscale: Thermal Wave Probe Made It Simple
11 April 2008

110. Prof. Dr. Dzolkhifli Omar
The Future of Pesticides Technology in Agriculture: Maximum Target Kill with Minimum Collateral Damage
25 April 2008

111. Prof. Dr. Mohd. Yazid Abd. Manap
Probiotics: Your Friendly Gut Bacteria
9 May 2008

112. Prof. Dr. Hamami Sahri
Sustainable Supply of Wood and Fibre: Does Malaysia have Enough?
23 May 2008

113. Prof. Dato' Dr. Makhdzir Mardan
Connecting the Bee Dots
20 June 2008

114. Prof. Dr. Maimunah Ismail
Gender & Career: Realities and Challenges
25 July 2008

115. Prof. Dr. Nor Aripin Shamaan
Biochemistry of Xenobiotics: Towards a Healthy Lifestyle and Safe Environment
1 August 2008

116. Prof. Dr. Mohd Yunus Abdullah
Penjagaan Kesihatan Primer di Malaysia: Cabaran Prospek dan Implikasi dalam Latihan dan Penyelidikan Perubatan serta Sains Kesihatan di Universiti Putra Malaysia
8 Ogos 2008

117. Prof. Dr. Musa Abu Hassan
Memanfaatkan Teknologi Maklumat & Komunikasi ICT untuk Semua
15 Ogos 2008

118. Prof. Dr. Md. Salleh Hj. Hassan
Role of Media in Development: Strategies, Issues & Challenges
22 August 2008

119. Prof. Dr. Jariah Masud
Gender in Everyday Life
10 October 2008

120 Prof. Dr. Mohd Shahwahid Haji Othman
Mainstreaming Environment: Incorporating Economic Valuation and Market-Based Instruments in Decision Making
24 October 2008

121. Prof. Dr. Son Radu
Big Questions Small Worlds: Following Diverse Vistas
31 Oktober 2008

122. Prof. Dr. Russly Abdul Rahman
Responding to Changing Lifestyles: Engineering the Convenience Foods
28 November 2008

123. Prof. Dr. Mustafa Kamal Mohd Shariff
Aesthetics in the Environment an Exploration of Environmental: Perception Through Landscape Preference
9 January 2009

124. Prof. Dr. Abu Daud Silong
Leadership Theories, Research & Practices: Farming Future Leadership Thinking
16 January 2009

125. Prof. Dr. Azni Idris
Waste Management, What is the Choice: Land Disposal or Biofuel?
23 January 2009

126. Prof. Dr. Jamilah Bakar
Freshwater Fish: The Overlooked Alternative
30 January 2009

127. Prof. Dr. Mohd. Zobir Hussein
The Chemistry of Nanomaterial and Nanobiomaterial
6 February 2009

128. Prof. Ir. Dr. Lee Teang Shui
Engineering Agricultural: Water Resources
20 February 2009

129. Prof. Dr. Ghizan Saleh
Crop Breeding: Exploiting Genes for Food and Feed
6 March 2009

130. Prof. Dr. Muzafar Shah Habibullah
Money Demand
27 March 2009

131. Prof. Dr. Karen Anne Crouse
In Search of Small Active Molecules
3 April 2009

132. Prof. Dr. Turiman Suandi
Volunteerism: Expanding the Frontiers of Youth Development
17 April 2009

133. Prof. Dr. Arbakariya Ariff
Industrializing Biotechnology: Roles of Fermentation and Bioprocess Technology
8 Mei 2009

134. Prof. Ir. Dr. Desa Ahmad
Mechanics of Tillage Implements
12 Jun 2009

135. Prof. Dr. W. Mahmood Mat Yunus
Photothermal and Photoacoustic: From Basic Research to Industrial Applications
10 Julai 2009

136. Prof. Dr. Taufiq Yap Yun Hin
Catalysis for a Sustainable World
7 August 2009

137 Prof. Dr. Raja Noor Zaliha Raja Abd. Rahman
Microbial Enzymes: From Earth to Space
9 Oktober 2009

138 Prof. Ir. Dr. Barkawi Sahari
Materials, Energy and CNGDI Vehicle Engineering
6 November 2009

139. Prof. Dr. Zulkifli Idrus
Poultry Welfare in Modern Agriculture: Opportunity or Threat?
13 November 2009

140. Prof. Dr. Mohamed Hanafi Musa
Managing Phosphorus: Under Acid Soils Environment
8 January 2010

141. Prof. Dr. Abdul Manan Mat Jais
Haruan Channa striatus a Drug Discovery in an Agro-Industry Setting
12 March 2010

142. Prof. Dr. Bujang bin Kim Huat
Problematic Soils: In Search for Solution
19 March 2010

143. Prof. Dr. Samsinar Md Sidin
Family Purchase Decision Making: Current Issues & Future Challenges
16 April 2010

144. Prof. Dr. Mohd Adzir Mahdi
Lightspeed: Catch Me If You Can
4 June 2010

145. Prof. Dr. Raha Hj. Abdul Rahim
Designer Genes: Fashioning Mission Purposed Microbes
18 June 2010

146. Prof. Dr. Hj. Hamidon Hj. Basri
A Stroke of Hope, A New Beginning
2 July 2010

147. Prof. Dr. Hj. Kamaruzaman Jusoff
Going Hyperspectral: The "Unseen" Captured?
16 July 2010

148. Prof. Dr. Mohd Sapuan Salit
Concurrent Engineering for Composites
30 July 2010

149. Prof. Dr. Shattri Mansor
Google the Earth: What's Next?
15 October 2010

150. Prof. Dr. Mohd Basyaruddin Abdul Rahman
Haute Couture: Molecules & Biocatalysts
29 October 2010

151. Prof. Dr. Mohd. Hair Bejo
Poultry Vaccines: An Innovation for Food Safety and Security
12 November 2010

152. Prof. Dr. Umi Kalsom Yusuf
Fern of Malaysian Rain Forest
3 December 2010

153. Prof. Dr. Ab. Rahim Bakar
Preparing Malaysian Youths for The World of Work: Roles of Technical and Vocational Education and Training (TVET)
14 January 2011

154. Prof. Dr. Seow Heng Fong
Are there "Magic Bullets" for Cancer Therapy?
11 February 2011

155. Prof. Dr. Mohd Azmi Mohd Lila
Biopharmaceuticals: Protection, Cure and the Real Winner
18 February 2011

156. Prof. Dr. Siti Shapor Siraj
Genetic Manipulation in Farmed Fish: Enhancing Aquaculture Production
25 March 2011

157. Prof. Dr. Ahmad Ismail
Coastal Biodiversity and Pollution: A Continuous Conflict
22 April 2011

158. Prof. Ir. Dr. Norman Mariun
Energy Crisis 2050? Global Scenario and Way Forward for Malaysia
10 June 2011

159. Prof. Dr. Mohd Razi Ismail
Managing Plant Under Stress: A Challenge for Food Security
15 July 2011

160. Prof. Dr. Patimah Ismail
Does Genetic Polymorphisms Affect Health?
23 September 2011

161. Prof. Dr. Sidek Ab. Aziz
Wonders of Glass: Synthesis, Elasticity and Application
7 October 2011

162. Prof. Dr. Azizah Osman
Fruits: Nutritious, Colourful, Yet Fragile Gifts of Nature
14 October 2011

163. Prof. Dr. Mohd. Fauzi Ramlan
Climate Change: Crop Performance and Potential
11 November 2011

164. Prof. Dr. Adem Kiliçman
Mathematical Modeling with Generalized Function
25 November 2011

165. Prof. Dr. Fauziah Othman
My Small World: In Biomedical Research
23 December 2011

166. Prof. Dr. Japar Sidik Bujang
The Marine Angiosperms, Seagrass
23 March 2012

166. Prof. Dr. Zailina Hashim
Air Quality and Children's Environmental Health: Is Our Future Generation at Risk?
30 March 2012

167. Prof. Dr. Zainal Abidin Mohamed
Where is the Beef? Vantage Point form the Livestock Supply Chain
27 April 2012

168. Prof. Dr. Jothi Malar Panandam
Genetic Characterisation of Animal Genetic Resources for Sustaninable Utilisation and Development
30 November 2012

169. Prof. Dr. Fatimah Abu Bakar
The Good The Bad & Ugly of Food Safety: From Molecules to Microbes
7 Disember 2012

170. Prof. Dr. Abdul Jalil Nordin
My Colourful Sketches from Scratch: Molecular Imaging
5 April 2013

171. Prof. Dr. Norlijah Othman
Lower Respiratory Infections in Children: New Pathogens, Old Pathogens and The Way Forward
19 April 2013

172. Prof. Dr. Jayakaran Mukundan
Steroid-like Prescriptions English Language Teaching Can Ill-afford
26 April 2013

173. Prof. Dr. Azmi Zakaria
Photothermals Affect Our Lives
7 Jun 2013

174. Prof. Dr. Rahinah Ibrahim
Design Informatics
21 Jun 2103

175. Prof. Dr. Gwendoline Ee Cheng
Natural Products from Malaysian Rainforests
1 November 2013

176. Prof. Dr. Noor Akma Ibrahim
The Many Facets of Statistical Modeling
22 November 2013

177. Prof. Dr. Paridah Md. Tahir
Bonding with Natural Fibres
6 Disember 2013