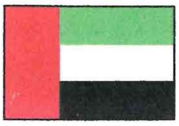

MISSION D'APPUI A LA THESE DE R. SEBOUSSI (EMIRATS ARABES UNIS)

Métabolisme du sélénium chez le dromadaire

du 13 au 20 décembre 2005

Bernard FAYE

Décembre 2005

Rapport n° : 2005/20

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RÉSUMÉ :

Cette seconde mission 2005 aux Emirats Arabes Unis était consacrée à l'appui de la thèse de Mademoiselle SEBOUSSI, inscrite à l'université de Montpellier II et dont j'assume la direction de la thèse dans le cadre de l'UMR ERRC en collaboration avec le Dr AL-HADRAMI de l'Université d'Al Ain.

Au cours de cette mission, les protocoles expérimentaux en cours ont été validés mais les données n'ont pu être traitées dans la mesure où les analyses de laboratoire ne sont pas encore terminées. Cependant, une seconde publication a pu être réalisée.

La mise en œuvre d'un congrès international est bien prévue en 2006 à Al-Ain. Il s'agit du premier congrès d'une Société des Recherches camélines dont les statuts sont établis. La programmation 2006 est proposée au SCAC.

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REMERCIEMENTS

J'adresse mes remerciements au Dr ALHADRAMI, Vice-Doyen de l'Université d'Al-Ain pour sa grande prévenance et sa collaboration dans le cadre de la future Société Internationale pour la recherche caméline et le développement (ISOCARD) et à Mademoiselle SEBOUSSI pour son accueil et sa motivation toujours aussi forte. Je remercie également le Service de Coopération de l'Ambassade de France qui ne manque pas d'appuyer la collaboration entre le CIRAD et l'Université des Emirats.

RESUME

Cette seconde mission 2005 aux Emirats Arabes Unis était consacrée à l'appui de la thèse de Mademoiselle SEBOUSSI, inscrite à l'université de Montpellier II et dont j'assume la direction de la thèse dans le cadre de l'UMR ERRC en collaboration avec le Dr AL-HADRAMI de l'université d'Al Ain.

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I - INTRODUCTION

Cette seconde mission appuyée par l'Ambassade de France aux Emirats Arabes Unis (EAU) était programmée dans le cadre de la convention de coopération qui lie le CIRAD à l'université des EAU (cf. les rapports précédents). La collaboration avec l'université des EAU s'est consacrée essentiellement sur la biologie des camélidés et la thèse de R. SEBOUSSI (inscrite à Montpellier II via l'UMR ERRC et conjointement à l'Université d'Al-Ain). Cependant un séjour scientifique de haut niveau a pu être réalisé dans le domaine de la protection des plantes à l'île de la Réunion au pôle 3P (Séjour du Pr. ALMASSOUM), montrant que cette collaboration peut toucher à d'autres aspects. Du reste, ce séjour a été déjà mis à profit et le Pr. ALMASSOUM a pu me montrer les premiers travaux de recherche réalisés suite à son séjour au CIRAD. Il a demandé d'ailleurs à ce qu'un doctorant français puisse venir travailler en collaboration avec lui aux Emirats. Un courrier sera adressé en ce sens au département du CIRAD concerné (FHLOR).

La mission actuelle était nécessaire dans la phase actuelle de validation des protocoles expérimentaux et pour l'analyse des premiers résultats. Cette mission devait également se consacrer à l'organisation du premier congrès de l'ISOCARD (*International Society oc Camel Research and Development*). En marge, il était question aussi d'organiser une conférence ouverte sur le thème des déséquilibres minéraux chez le dromadaire.

II - BREF RAPPEL HISTORIQUE DE LA COOPERATION CIRAD/Université des EAU

La collaboration avec l'Université des Emirats Arabes Unis a été entamée en 1998 avec une invitation à Al-Ain au meeting annuel sur les productions animales en régions chaudes où j'avais présenté les résultats des travaux de recherche menés en coopération avec l'Institut Agro-vétérinaire Hassan II de Rabat (Maroc) sur le métabolisme des éléments-traces chez le dromadaire. Sur le plan de la coopération avec l'Université d'Al-Ain, contacts avaient été pris avec le Pr. ALHADRAMI, Doyen de la Faculté des sciences agronomiques, pour co-encadrer une thèse d'un étudiant d'origine tunisienne.

Toutefois, ce projet n'a pu aboutir faute des financements un moment espérés. Réinvité au même type de réunion en 2001, j'en avais profité pour proposer à nouveau un co-encadrement de thèse qui cette fois-ci a abouti. Je me suis ciblé sur un projet de thèse portant sur le métabolisme du Sélénium dont on fait apparemment un usage immodéré dans les Emirats. Ce travail de thèse est en cours avec Mademoiselle Rabiya SEBOUSSI (cf. plus loin).

Des échanges d'étudiants ont été également proposés : M. Mahfoud GASMI, étudiant du DESS « Productions Animales en Régions Chaudes » du CIRAD en 2003 (mais cet étudiant d'origine marocaine n'a pas donné satisfaction) et Mademoiselle Melinda COLLET, étudiante vétérinaire de l'Ecole Nationale Vétérinaire de Toulouse, qui doit venir début 2006.

Une convention de coopération ayant été signée entre le CIRAD et l'université des EAU avec l'appui de l'ambassade, il a été proposé d'élargir la thématique de la collaboration sur d'autres aspects que les seuls camélidés et une mission commune avec M. Max REYNES, actuellement responsable de l'UR Qualité au CIRAD/département horticulture a pu se réaliser. Une visite scientifique pour un professeur de l'université dans le domaine de la culture sous serre a pu être organisée à l'île de la Réunion où le CIRAD a un dispositif expérimental de pointe.

On peut affirmer que, globalement cette coopération fonctionne bien et que la confiance entre les partenaires est totale.

III - RAPPORT D'AVANCEMENT DE LA THESE

Le travail de thèse de Mademoiselle R. SEBOUSSI avance approximativement selon le calendrier prévu. Ce travail comprenait 4 expérimentations concernant le métabolisme du sélénium chez le dromadaire :

1. L'expérimentation 1 est terminée et publiée. Une seconde publication concernant les métaux lourds est également terminée (cf annexe : FAYE B., SEBOUSSI R., ASKAR M., 2005. *Trace elements and heavy metals in healthy camel blood of United arab Emirates*. J. Camel Res. Pract., 12, 1-6).
2. L'expérimentation 2 est terminée également (effet de différents niveaux de complémentations sur le statut en sélénium) et les analyses sont toujours en cours.
3. L'expérimentation 3 est également terminée, (essai de tolérance et de toxicité au sélénium sur des chamelons), mais les analyses de laboratoire non encore achevées.
4. L'expérimentation 4 est en cours (elle concerne 12 chamelles gestantes). Toutefois, aucune toxicité au sélénium n'ayant été obtenue lors de l'expérimentation 3, il est envisagé une expérimentation 5 sur l'intolérance au sélénium chez le jeune chamelon (cf. annexe).

Les analyses pour le dosage de la glutathion peroxydase, enzyme liée au sélénium et dont le dosage n'est pas réalisé en routine, vont enfin pouvoir se faire. L'article mentionnant le détail de la méthode (Piagla et Valentine, 1967) est disponible. La venue d'une stagiaire française (Mademoiselle Mérinda COLLET) de l'école nationale vétérinaire de Toulouse pendant 6 semaines au début 2006, devrait faciliter une accélération dans la réalisation des analyses.

Enfin, Mademoiselle SEBOUSSI a pu bénéficier d'un séjour d'un mois en France pour participer à la formation gestion et traitement des données d'élevage, ce qui lui a permis de mieux maîtriser les méthodes de gestion des bases de données (mise en place d'une base de données sous Access) et quelques aspects de l'analyse des données. Cette formation est déjà mise à profit pour l'aspect base de données, mais demande encore un compagnonnage pour le traitement des données.

Au cours de ce séjour, deux projets d'articles ont commencé à être rédigé sur les parties introduction, matériel et méthodes et références bibliographiques :

1. **Effect of different selenium level supplementation on selenium status in camel from United Arab Emirates** (publication prévue dans *Biological trace element research*)
   Auteurs : R. SEBOUSSI, M.ASKAR, K. HASSAN, G. ALHADRAMI, B. FAYE
2. **Selenium distribution in camel blood and organs for different levels of supplementation** (publication prévue dans *Animal Sciences*).
   Auteurs: R. SEBOUSSI, M.ASKAR, K. HASSAN, G. ALHADRAMI, B. FAYE

Un troisième est en cours et s'appuie sur l'expérience menée actuellement. Il s'intitule :

3. **Selenium metabolism in pregnant and lactating camel** (publication envisage dans *Journal of Dairy Sciences*). Il s'agit des mêmes auteurs.

Enfin, à la demande du Pr. AL-HADRAMI, un court article est proposé pour annoncer les travaux en cours sur le métabolisme du sélénium chez le dromadaire dans la revue Al-Asail. Cette revue destinée aux éleveurs de dromadaires, éditée en arabe, paraît régulièrement et permettra de montrer les travaux en cours, sachant que la revue est pilotée par un des partenaires du projet (qui y contribue de façon très significative, la plupart des analyses étant réalisée gratuitement). On trouvera en annexe ce projet d'article.

Au cours de la présente mission, il m'a été demandé aussi de donner une conférence sur « les déséquilibres minéraux chez le dromadaire », organisée par la municipalité d'Al-Ain. Cette conférence a eu un bon succès avec une participation d'environ 80 personnes et un débat très riche qui a duré plus d'une heure et demi, ce qui est remarquable pour un sujet aussi pointu. On trouvera l'annonce de cette conférence en annexe ainsi que la présentation qui en a été faite.

IV - ORGANISATION DE LA PREMIERE CONFERENCE de l'ISOCARD

Le Dr ALHADRAMI est déterminé à co-organiser le premier congrès international de l'ISOCARD (*International Society of Camelid research and development)* sur les camélidés en 2006, la conférence internationale prévue en novembre de cette année en Arabie Saoudite ayant été annulée. La date a été arrêtée du 16 au 18 avril, ce qui est très tôt dans l'année, mais les dispositions sont prises pour une organisation optimale. Les fondateurs de l'ISOCARD sont outre moi-même, le Pr. ALHADRAMI (EAU), le Pr. BENGOUMI (IAV Hassan II) et le Pr. TIBARY (Université de Washington, USA). On trouvera en annexe, l'annonce de ce premier congrès. Il s'agit d'un point très important de la coopération en cours. Outre le fait d'en être le co-organisateur avec l'IAV Hassan II et être membre du Comité Scientifique, il représente une consécration évidente de la coopération qui est menée dans le domaine de la camélologie.

V - CONCLUSION

Le travail de thèse sur le métabolisme du sélénium chez le dromadaire avance selon le calendrier prévu et devrait conforter l'intérêt d'une espèce comme modèle biologique. Rappelons, par ailleurs, que la carence en sélénium représente un important problème économique pour l'élevage camélin dans les Emirats même si la mortalité diminue grâce à une politique préventive accrue.

Enfin, la mise en œuvre du premier congrès mondial de l'association des sciences camélines à Al Ain en 2006 représente un enjeu majeur pour les chercheurs s'intéressant à cette espèce et un défi pour notre collaboration qui prend, par cette manifestation, un caractère tout à fait novateur et stimulant. La demande formulée pour disposer en commun avec le CIRAD-FHLOR d'un doctorant dans le domaine de la protection des plantes et des cultures sous serre indique également que l'ouverture vers d'autres productions que les seules productions animales représente un encouragement à l'élargissement de la collaboration.

Sur le plan de la communication, l'université réalise un film sur la coopération internationale et c'est notre projet qui est pris en exemple : interview et filmage de l'expérimentation en cours.

ANNEXES

ANNEXE 1 -	Calendrier et personnalités rencontrées
ANNEXE 2 -	Article publié dans *Journal of Camel Practice and Research*
ANNEXE 3 -	Présentation powerpoint de la conférence sur les déséquilibres minéraux chez le dromadaire
ANNEXE 4 -	Annonce du premier congrès de l'ISOCARD
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ANNEXE 1

Calendrier et personnalités rencontrées

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Calendrier et personnalités rencontrées

Mardi 13 décembre

- Départ de Montpellier
- Arrivée à Dubaï
- Transfert à Al-Ain en taxi

Mercredi 14 décembre

- Séance de travail à la ferme expérimentale (prélèvements de sang, d'urine, de fèces et de lait (expérimentation 3 sur les femelles gestantes) en présence de la télévision (préparation d'un film sur la coopération internationale à l'Université des EAU)
- Entretien avec le Dr ALHADRAMI
- Séance de travail au laboratoire privé du Cheikh
- Séance de travail à l'université (préparation du protocole de tolérance au sélénium)

Jeudi 15 décembre

- Entretien avec les Drs Tarek Mustapha et Dr Aboubaker EL-KHOULY (Laboratoire vétérinaire)
- Séance de travail à l'université (discussion sur le stage de Melinda COLLET, étudiante de l'ENV de Toulouse en stage pour 6 semaines)

Vendredi 16 décembre

- Séance de travail à l'université : rédaction des articles et préparation de la conférence du 19 decembre.

Samedi 17 décembre

- Entretien avec le Pr. Al-MASSOUM (Professeur ayant été au CIRAD-Réunion dans le domaine des protections des plantes)
- Entretien avec M. V. HEGARTY, doyen de l'université
- Entretien avec le Pr. AL-HADRAMI : préparation de la conférence internationale de l'ISOCARD
- Rédaction de l'article pour Al-Asail

Dimanche 18 décembre

- Essai à la ferme al-Foah
- Visite du marché au bétail
- Montage audiovisuel sur la coopération internationale.
- Préparation de la future conférence internationale

Lundi 19 décembre

- Interview pour le montage audiovisuel
- Départ pour Abu-Dhabi.
- Entretien avec J.J. GROUSSEAU et R. CHAFFORT au service de Coopération de l'Ambassade de France
- Retour à Al-Ain
- Conférence sur les déséquilibres minéraux chez le dromadaire à la municipalité d'Al-Ain

Mardi 20 septembre

- Départ pour Dubaï et retour sur Montpellier
- Arrivée à Montpellier

ANNEXE 2

Article publié dans *Journal of Camel Practice and Research*

Article publié dans *Journal of Camel Practice and Research*

Références : FAYE B., SEBOUSSI R., ASKAR M., 2005. *Trace elements and heavy metals in healthy camel blood of United arab Emirates.* J. Camel Res. Pract., 12, 1-6

Trace elements and heavy metals in healthy camel blood from United Arab Emirates

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ABSTRACT

In the Emirates, camel rearing is an important cultural fact. In the present paper, 240 camels were sampled for the determination of trace elements and different heavy metals. The following elements were tested: copper, zinc, iron, aluminium, arsenic, boron, barium, cobalt, chromium, cadmium, manganese, molybdenum, nickel, selenium, strontium and lead. The variation factors included age, sex and physiological status. On the average, the mineral contents were 190.3 µg/100ml (iron), 60.1 µg/100ml (copper), 44.0 µg/100ml (strontium), 22.5 µg/100ml (arsenic), 20.0 µg/100ml (zinc), 19.7 µg/100ml (selenium), 19.3 µg/100ml (boron) and 14.6µg/100ml (barium). Other minerals like aluminium (3.7 µg/100ml), molybdenum (2.9 µg/100ml), chromium (2.0 µg/100 ml), nickel (1.8 µg/100ml), lead (1.5 µg/100ml), manganese (0.16 µg/100ml), cobalt (0.08 µg/100ml) and cadmium (0.07 µg/100ml) were in very small concentration. Age, sex and physiological effects were assessed for some parameters.

INTRODUCTION

The main trace elements in camel blood (copper, zinc, iron) were commonly determined in several countries where camel is an important part of the livestock economy. Some reviews are now available in the literature (Faye and Bengoumi, 1994; Abu Damir, 1998; Faye and Bengoumi, 2000). Normal ranges and deficiency statuses are described in numerous cases. However, the data on other trace elements and some heavy metals are scarce. The importance of those other trace elements and their potential toxicity is more and more described in other species as small ruminants and cattle. In camel, the references are very few or, for some elements, are non-existent in published papers. In Arab Emirates, the racing camel has a central cultural place in the leisure of population. The racing activity has a strong effect on the metabolism and physiology of the camel (Rose et al., 1994). Those animals have specific mineral requirements under effort. The determination of a wide type of trace elements could be beneficial for a better understanding of the specific physiology of sport animal in desert conditions.

In the present paper, copper, zinc, iron which are classically determined in camel blood are enriched by the determination of other minerals as aluminium, arsenic, boron, barium, cobalt, chromium, cadmium, manganese, molybdenum, nickel, selenium, strontium and lead. Some of these elements are biologically essential, some others are potentially toxic.

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MATERIAL AND METHODS

Animals

The animals were provided by Al-Ochouche farm at Al-Ain Emirates including 3000 dromedary camels (*Camelus dromedarius*) in extensive management of three breeds adapted to race: local, Sudanese and crossbred. As the whole, 240 animals between 2 and 10 years old were randomly selected for the present study. Before blood collecting, a general examination of all the selected camels was achieved and only healthy animals were retained. To discard the animals with trypanosome, common disease in Arab Emirates, a diagnosis was performed by three different tests: mercury chlorate test, agglutination test and blood examination test according to Woo method (Woo, 1971). Each positive animal at one of the test was discarded. A faecal examination for internal parasites diagnosis was achieved according floating method (Soulsby, 1982).

Finally, the analyses were achieved in 235 animals. The camel sample wad shared into two groups according the gender. The sample included 83 males and 152 females; a part of the she-camels was pregnant (n = 68), 55 non pregnant and 29 lactating. Each dromedary camel was identified by a number tied to the neck. The males and females animals were distributed into 3 age classes, respectively 3-4 years, 5-7 years and 8 years and more. The males were mainly less than 4 years old (n = 51) or mature breeding animals more than 8 years old (n = 32). Females less than 4 years old were 49. The number of females in other classes was respectively 97 (class 5-7 years) and 6 (8 and more). On the whole population, 156 were local breeds, 6 Sudanese only and 73 crossbreed.

Animals were fed with a basal diet including green alfalfa, commercial concentrate, dates and a mixture of three types of lentils. They were watered *ad libitum*. No specific mineral supplementation was given for the experimental time except Selenium and vitamin E regularly introduced in the commercial supplement.

Blood sampling

After disinfection of the skin at the upper part of the neck with iodine alcohol, blood was collected at jugular vein with sterile syringe in two 10 ml tubes without EDTA. Those samples were carried later to the laboratory for analyses performed immediately after collecting.

The collected samples were centrifuged at 4300 t/min for 5 min. The main trace elements (Zn, Cu, Fe) were determined after separation of serum by atomic absorption spectrophotometer according to the classical method of Bellanger and lamand (1975). The kit used came from company *Dade Boehring USA*. Those analyses were achieved at the veterinary lab of agricultural department at Al-Ain.

The other mineral analysis (Al, As, B, Ba, Cd, Co, Cr, Mn, Mo, Ni, Pb, Se, Sr) were achieved on serum stored at 4°C before analysis according to the Brown and Watkinson method (1977). The samples were digested for destroying proteins and amino acids in order to separate the minerals linked to proteins. This first step was performed at the private department of H. H. Sheikh Zayed Bin Sultan Al-Nahyan, in the scientific centre of racing camel, Al-Ain. The concept is to mix in the 6 tubes of the rotator in a microwave digestor, 2ml serum, 6ml hydrogen peroxide (H_2O_2) at 30%, then 1ml nitric acid (HNO_3) at 60%. The tubes are placed in the rotator by increasing order from 1 to 6 and well tighted, then introduced in the apparatus. After serum digestion, the sample was poured in sterile tube, then exported to Al-Salamate lab analysis –Al Ain for determining the minerals with an ICP (Induced coupled plasma *Varian Vista MPX-CCD)*.

Statistical analysis

The differences between groups (age classes, sex groups, physiological status groups, breeds) were tested by variance analysis according to the procedure General Linear Models (GLM) with R software ©. If the probability (p) was below 0.05, the differences between groups were considered as significant. The correlation of Pearson between the analysed elements was calculated. The interactions between variation factors were taken in account in statistical models.

RESULTATS

To facilitate the comparison, all the results are expressed in µg/100ml. On average, the main trace element in camel serum were iron (190.3 µg/100ml) followed by copper (60.1 µg/100ml), strontium (44.0 µg/100ml), arsenic (22.5 µg/100ml), zinc (20.0 µg/100ml), selenium (19.7 µg/100ml), boron (19.3 µg/100ml) and barium (14.6µg/100ml). Other minerals like aluminium (3.7 µg/100ml), molybdenum (2.9 µg/100ml), chromium (2.0 µg/100 ml), nickel (1.8 µg/100ml), lead (1.5 µg/100ml), manganese (0.16 µg/100ml), cobalt (0.08 µg/100ml) and cadmium (0.07 µg/100ml) were in very small concentration.

Age effect (table 1)

There was no observed age effect on Al, Ba, Cd, Co, Cr, Cu, Mn, Mo, Ni, Pb and Sr. When an age effect was reported (table 1), the young adult animals (5 to 7 years old) had a significant higher concentration of arsenic (28.3 µg/100ml), boron (35.8 µg/100ml) and selenium (28.1µg/100ml). The oldest animals more than 8 years old had highest values of iron (283 µg/100ml). However, the differences between age groups were low. Concerning zinc, a significant lower value was reported in group 2 (5-7 years old).

groups	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Se	Sr	Zn
3-4 y	2.1	18.7	7.1	15.4	0.06	0.07	2.5	57.7	174.1	0.20	3,0	1.8	1.6	14.1	44.0	25.6
5-7 y	6.6	28.3*	35.8**	14.5	0.09	0.02	1.6	62.9	171.5	0.07	3.6	1.7	1.2	28.1**	44.6	12.1**
>7y	0.7	17.9	9.3	12.7	0.16	0.28	1.8	59.0	283.8**	0.29	1.2	1.9	1.8	12.4	42.3	25.1

Table 1. Mean values of trace elements and heavy metals in camel serum according to age groups (in µg/100ml).
* $p < 0.05$; ** $p < 0.01$

Sex effect (table 2)

Some elements (As, Ba, Cd, Co, Cr, Mn, Mo, Pb) had similar values between sex. Females had significant higher values of boron (23.3 µg/100ml), copper (61.9), selenium (22.9) and strontium (47.6). Aluminium was also slightly higher in female (4.6 µg/100ml). Iron value was significantly higher in male (213.1 µg/100ml), as far as zinc (24.3 µg/100ml). Nickel was slightly higher in male also (2.0 *vs* 1.7).

groups	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Se	Sr	Zn
male	2.1	22.3	11.9	14.7	0.17	0.16	2.6	56.7	213.1**	0.24	2.2	2.0*	1.7	13.6	37.4	24.3**
female	4.6*	22.6	23.3**	14.6	0.02	0.04	1.6	61.9**	177.8	0.12	3.3	1.7	1.3	22.9**	47.6**	17.6

Table 2. Mean values of trace elements and heavy metals in camel serum according to sex groups (in µg/100ml).
* $p < 0.05$; ** $p < 0.01$

Physiological status effect (table 3)

As for former variation factors, no effect of the physiological status was observed for Cd, Co, Cr, and Mo. Elsewhere, Ba, Cu, Mn, and Ni did not change according to the status of the female (non pregnant, pregnant or milking). In non pregnant animals, strontium (52.9 µg/100ml), iron (189.1µg/100ml) and zinc (27.3) were in higher concentration in plasma while selenium was significantly lower (13.8). In pregnant animals, values of copper were slightly higher but no significantly (64.7 µg/100ml). In milking animals, significant higher values of arsenic (32.4 µg/100ml), boron (51.7 µg/100ml) and aluminium (10.2 µg/100ml) were observed.

groups	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Se	Sr	Zn
No-preg	1,0	12.7	1.3	14.7	0.02	0.06	1.8	60.2	189.1*	0.19	2.9	1.7	1.6*	13.8**	52.9**	27.3**
pregnant	5.1	26.5	29.1	15.7	0.03	0.03	1.6	64.7	174.7	0.10	2.5	1.7	1.7	28.1	45.9	13.5
milking	10.2**	32.4**	51.7**	11.7	0.00	0.00	1.5	58.9	163.9	0.00	6.2	1.9	1.7	28.2	41.5	8.9

Table 3. Mean values of trace elements and heavy metals in camel serum according to physiological status groups (in µg/100ml).

* $p < 0.05$; ** $p < 0.01$

Breed effect (table 4)

Few elements change according to the breed. The observed differences were slightly significant. Boron is slightly lower in crossbreed group (11.7 µg/100ml *vs* 22.7 in other groups). Arsenic was also lower in crossbreed group (19.8 µg/100ml *vs* 23.8 and 21.5 in the other breeds).

groups	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Se	Sr	Zn
local	4.3	23.8*	22.7	14.6	0.06	0.07	2.1	61.0	198.3	0.12	2.5	1.8	1.4	19.6	45.1	19.0
Crossbr.	2.0	19.8	11.7*	14.8	0.02	0.02	1.7	58.3	176.3	0,21	3.7	1.7	1.4	19.5	40.6	22.0
Sudanese	9.7	21.5	22.7	13.9	0.24	0.28	1.9	58.4	153.4	0,54	5.8	1.9	3.2	20.9	56.4	21.0

Table 4. Mean values of trace elements and heavy metals in camel serum according to breed groups (in µg/100ml).

* $p < 0.05$; ** $p < 0.01$

Interactions

The interaction age*sex was observed for boron and selenium only ($p < 0.01$), essentially because no males belonged to age group 2 where highest values of B and Se were observed.

DISCUSSION

Except for copper, zinc, iron and in a less extent selenium, the references concerning trace element concentrations in camel blood, serum or plasma are quite marginal. The discussion will concern first the main trace elements as copper, zinc, manganese, iron and selenium, secondly the rarely analysed trace elements (aluminium, boron, barium, chrome, cobalt, molybdenum, nickel and strontium) and last the toxic minerals (arsenic, cadmium, lead)

The main trace elements

Serum or plasma **copper** is a good reflect of copper intake. In ruminants, normal copper concentrations are between 70 to 120 µg/100ml (i.e. 12 and 19µmol/l). Most of the reported values in camel are inside those thresholds (Faye and Bengoumi, 1994). With a mean value close to 60 µg/100ml, the copper status of the camel in our study is at the deficiency limit. In the literature, no significant variation due to sex was reported (Abdalla et al., 1988; Bengoumi et al., 1995), but the change along the gestation was observed (Liu et al., 1994) with a decrease of copper concentration at the end of pregnancy, contrary to our results. The results concerning age effect are contradictory: no significant difference (Faye and Mulato, 1991; Bengoumi et al., 1995), higher value on camels more than 5 years old (Marx and Abdi, 1983) as for the present study.

As for copper, **zinc** concentration in plasma or serum for most of the ruminants is between 70 and 120 µg/100ml. The present results confirm that it is not the same for camel as it has been already published. Indeed, normal values in camel are around 30 to 50 µg/100ml (Faye et al., 1992). In the present study, the zinc values are below these limits in most of the cases and vary between 0.2 and 115 µg/100ml. Low values were already reported in Emirates (Abdalla et al., 1988) and zinc deficiency was commonly suspected in the camel stock from this part of the world.

The age and sex variations of plasma or serum zinc were rarely reported. Young camels below 2 years have generally lower values (Faye et al., 1995). The highest values observed by some authors on non weaning camel calves are due to the milk feeding which provides sufficient zinc in the diet. A decreasing of zinc concentration was observed at the end of gestation in some studies (Faye and Mulato, 1991) as we reported in the present study. This decreasing could be linked to an active transfer of plasma zinc to the foetus. In Bactrian camel, similar trends are observed in pregnant animals (Liu et al., 1994). In our sample, the values in milking camel are very low, but no clinical symptoms of zinc deficiency were observed. These very low values, probably due to zinc transfer into the milk, could explain the sex difference reported in our sample, the lowest values being reported in milking animal. A recent study has shown an active transfer of zinc in camel milk (Cattaneo et al., 2005).

Manganese can be a limiting factor of the mineral diet in ruminants and deficiencies can be locally present according to the low values of some grasses in southern countries (Faye et al., 1986). Usually the quantity of manganese in blood is very low and can be detected only recently with high accuracy thanks to sophisticated apparatus as ICP. The mean values reported in the literature vary from 8.4 µg/100ml in Morocco (Bengoumi et al., 1994) to 30 µg/100ml in Egypt (Eltohamy et al., 1986). In ruminants, the values of blood manganese concentration are generally below 10 µg/100ml (Lamand, 1987). No variations factors were reported in the literature. In our sample, the values are effectively very low with a wide range (1.64 $\pm$ 6.69 µg/ml) and very slight difference was observed according to physiological status. Probably, the transfer to foetus, then to milk could explain the low plasma values in pregnant and milking female.

Iron is a common element of the nature, especially in tropical conditions. It is the most important element in the blood which contributes to haemoglobin composition. The references on plasma, serum or whole blood iron in camel are common. In serum, the values vary on average from 98 µg/100ml (Tartour, 1970) to 186 µg/100ml (Moty et al., 1968). In Emirates, Abdalla et al. (1988) reported mean values at 113 µg/100 ml. Our results are in the upper limit of those published data.

As for other main trace elements, iron decreased in pregnant and milking camel (Eltohamy et Salama, 1986). However, this change is not significant in our results. The iron concentration is generally higher in adult camels (Marx et Abdi, 1983; Shekhawat *et al,* 1987; Ghosal et Shekhawat, 1992) as in our sample. Concerning sex effect, the results in the literature are quite contradictory (Faye and Bengoumi, 1994). Our results mentioning a higher mean value in males are only in accordance with those of Hussein *et al.* (1997).

The **selenium** deficiency was described in young camel by several authors (Finlayson *et al,* 1971; Hamliri *et al,* 1990; Musa et Tageldin, 1994). In whole blood, Hamliri *et al*., (1990) reported values between 10.9 and 11.8 mg/100ml in Morocco. No age or sex effect was observed. Similar values involving Bactrian camels were published in China (Liu *et al.,* 1994) with 9.7 to 11.4 µg/100ml. Higher values (28.1 µg/100ml) were observed in camel plasma from Oman (unpublished data).

In a trial including a supplementation period (Bengoumi et al., 1998), the mean plasma selenium concentration in camel was 2.1 µg/100ml (before supplementation), 12.9 (during supplementation) and 8.3 (after supplementation period). The maximum mean value was observed the day before the end of supplementation period: 20.1 µg/100ml. According to Liu *et al.,* (1994), selenium concentration did not change according to the physiological status. In Emirates, selenium supplementation in pregnant camels was common. This practice explained the highest values reported in pregnant and milking females, and in age group 2 (due to interaction sex*age).

Rare trace elements and heavy metals

The **cobalt** concentration is generally very low in the plasma (Lamand, 1987). There is no data on cobalt in dromedary camel blood. Some results are available in Bactrian camel from Mongolia and China. According to Burenbayar (1989), cobalt concentration in blood varied from de 3.4 to 13.2 µg/100ml according to the season and mineral supplementation but the analysis method was not given. By atomic absorption spectrometry, Liu *et al,* (1994) reported blood cobalt concentration at 39 μg/100ml in non-pregnant camel, 56 μg/100ml in pregnant female and 53 μg/100ml after parturition, without significant difference. These values are quite higher than our results (0.08 μg/100ml in average). The analyzing method could be debatable for the previous studies.

Molybdenum is generally in competition with copper. Excess of molybdenum associated with sulphur is known to decrease copper digestibility in ruminants. Some cases of molybdenosis were described in camels grazing bush with *Salvadora persica* as predominant plant (Faye et Mulato, 1991). In Bactrian camel blood, molybdenum concentration was between 19 to 23 μg/100ml according to Liu *et al.*, (1994) and 0.43 to 0.53 μg/100ml only for Ma (1995). Our values are intermediate between those published results. No pregnancy effect was observed in Bactrian camel (Liu *et al.*, 1994).

No **nickel** plasma values were reported in camel, in spite of the recent interest for nickel in ruminants. In Mongolia, a "roll disease" linked to nickel intoxication was described in Bactrian camel (Tao *et al*, 1995).

Lead is a toxic element which can have an interest as indicator of environment pollution. No case of lead intoxication was described in camel. Elamin and Wilcox (1992) reported lead concentration in camel milk from Saudi Arabia: 180 μg/g DM that seems considerable. In cow blood, lead concentration is generally between 0.6 and 4.8 μg/100ml (Jeffrey et al., 2003).

No data was available for the other elements in camel. **Aluminium, chromium** and **strontium** were analyzed in muscle and hump fat, but only traces were observed. In dairy cow, blood concentration of chromium in non supplemented animals was between 0.33 and 0.42 μg/100ml according to Pechova et al. (2002). Generally in cow, **cadmium** is below 0.1μg/100ml

CONCLUSION

Except for the main trace elements, very few data or even no data are available to compare those results to the literature concerning camel. The camel seems to be less efficient than other ruminants as the goat to detoxify its organism (Al-Qarawi and Ali, 2003), so the sensitivity of camel to some toxic elements could be more important. It is expected that other determinations of heavy metals and toxic elements in blood and other biological fluids will be achieved to enlighten the standard values in this species.

Acknowledgements
We are grateful to the institutions and their directors which gave us all facilities to achieve the analysis: (i) Municipality and Agriculture Department- His Excellency Jumaa Saeed Hareb Al Amimi, (ii) Scientific Center for Racing Camel. Dr. Jawad Al Massri, (iii) Al Salamat Laboratory- Eng .Omar.

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ANNEXE 3

CONFÉRENCE DU 19/12/05

CONFÉRENCE DU 19/12/05

إمارة أبوظبي

دائرة البلديات والزراعة / قطاع الزراعة

تحت رعاية

سعادة/ جمعة سعيد حارب

وكيل دائرة البلديات والزراعة /قطاع الزراعة

تنظم الدائرة بالتعاون مع قسم زراعة الأراضي القاحلة –

–كلية التغذية والزراعة– جامعة الأمارات

وضمن البرنامج الثقافي لقسم الثروة الحيوانية ندوة علمية

بعنوان

تعليقات حول إختلال إتزان المعادن في الجمال

(Comments on Mineral imbalance in camels)

Prof.Bernard Faye

Project manager on animal resources

CIRAD

وذلك في قاعة المحاضرات بمبنى الدائرة بالعين في تمام الساعة السادسة مساءً

يوم الأثنين الموافق *19* ديسمبر **2005**

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ANNEXE 4

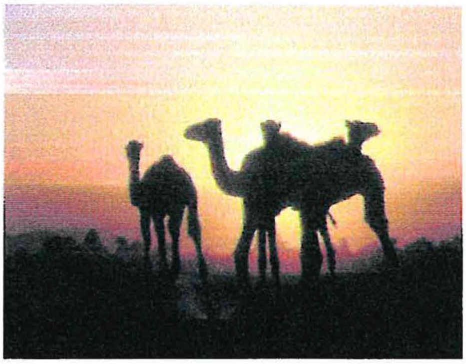
Annonce du premier congrès de l'ISOCARD

Annonce du premier congrès de l'ISOCARD

The International Society for Camelid Research and Development

ISOCARD*

Invites you to its first International congress on Camelid research



Al-Ain (United Arab Emirates)
16-18 april 2006

*ISOCARD will organize international congress every 3 years

What is ISOCARD?

The Association is a non-political, non-religious and non profit federation of camelid scientist or similar scientific and professional associations

Its objectives:

To give international scientific status for camelid sciences.
To promote the camelid science and practice.
To promote the contributions of camelid scientists to the development of camelid farming
To promote scientific publications in camelid fields.
To set high standards in camelid education and training.
To promote standards of health and welfare in camelids.
To organise International camelid Congresses every 3 years.
To encourage the exchange of information on camelid interest between the members and different networks and involved organisations.
To establish and maintain relations with other organisations whose interests are related to the objectives of the association.

Membership

The membership shall consist of:

- Camel scientists
- Associate members (Private companies, breeder association...).
- Honorary members

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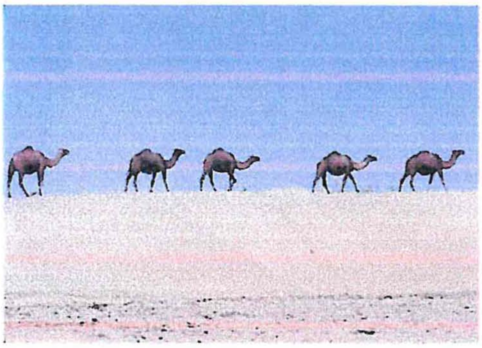
Foundators

Dr Bernard FAYE (France)
Dr Mohammed Bengoumi (Morocco)
Dr Ahmed Tibary (USA)
Dr Ghaleb Alhadrami (UAE)
General secretary
Dr David Anderson (USA)
North-America representative

General Topic of the first International congress of ISOCAR

Session 1. The camelids as a biological model
Biochemistry, pharmacology, physiology, immunology
Session 2: the camelids as a productive animal
Animal husbandry, production, feeding resources, reproduction, veterinary sciences and welfare
Session 3: the camelids as an element of the ecosystem
Camelids and environment, Camelids and development



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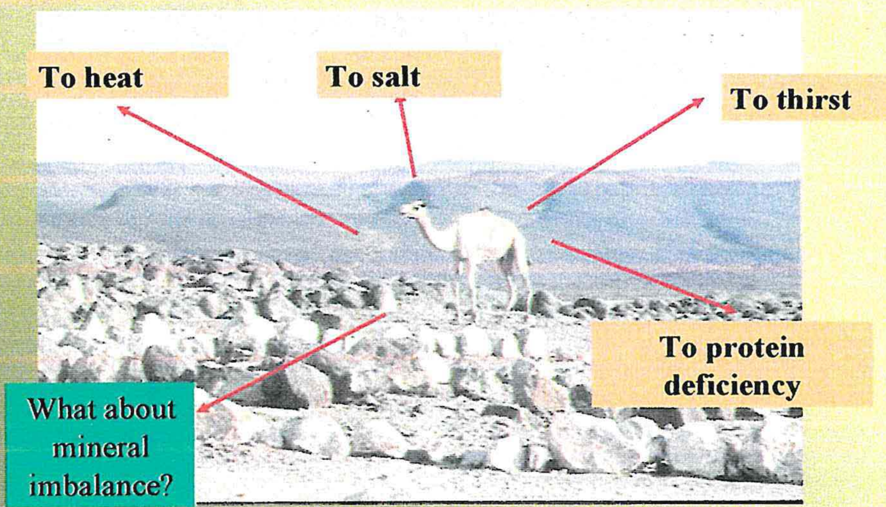
ANNEXE 5

Présentation POWERPOINT de la conférence sur les déséquilibres minéraux chez le dromadaire

Comments on mineral imbalance in camels

B. Faye CIRAD-EMVT, France

Adaptability of the camel



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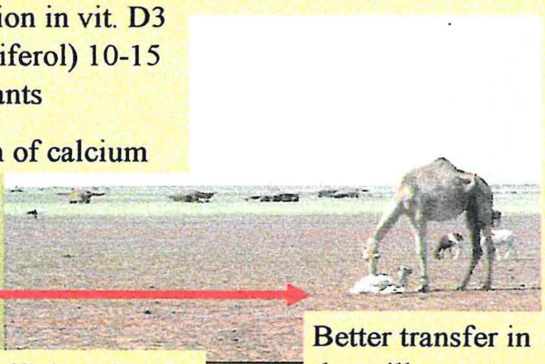
Calcium and phosphorus

The plasma concentration in vit. D3 (1,25dihydrocholecalciferol) 10-15 fold > ruminants

=> better assimilation of calcium



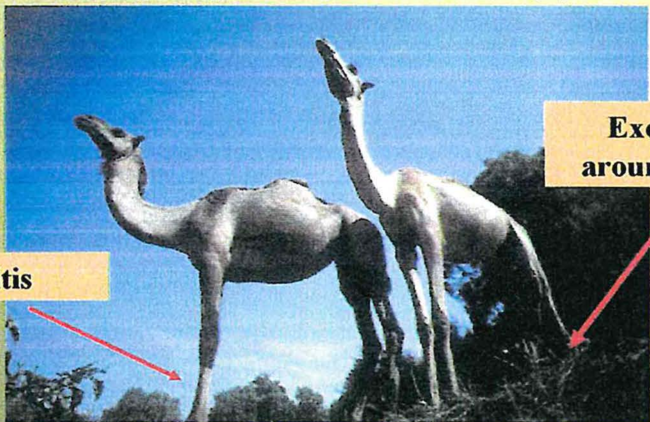
The true absorption coefficient (TAC) = 40% (Ca) and 65% (P) *vs* 15 and 30% for other ruminants

Better transfer in the milk

The *Kraff disease*

(phosphocalcium deficiency)

arthritis

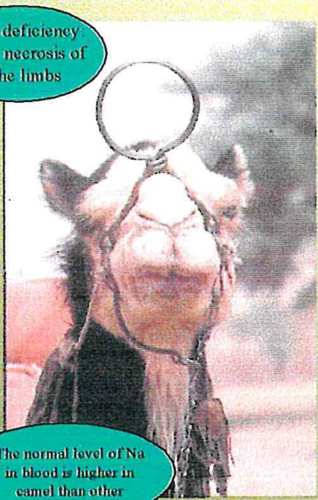


Exostoses around joints

Painful gait, paralysis

Sodium and chloride

Salt deficiency: skin necrosis of the limbs



The normal level of Na in blood is higher in camel than other ruminants

Hypernatremia and hyperchloruremia in case of dehydration

⇓

High salt requirements in camel (20g/100kg LW) => salted cure

Potassium

Slight hyper kaliemie and kaliurie (3% more) in case of dehydration)

→ Electrolytic balance maintained in case of dehydration

Magnesium

No specific requirements

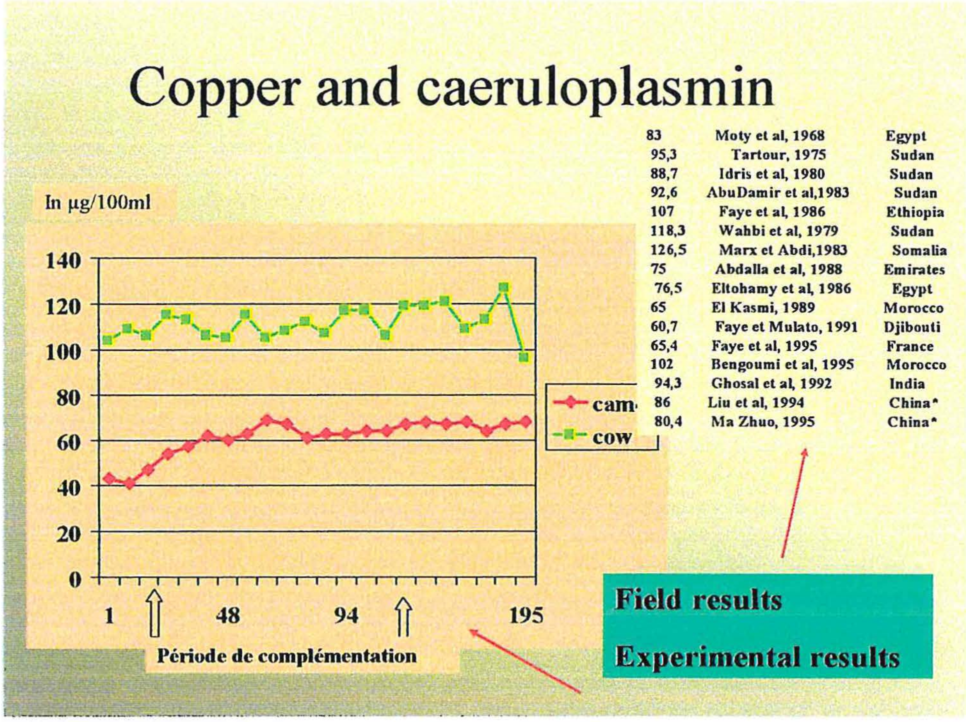
Hypomagnesmia rarely described

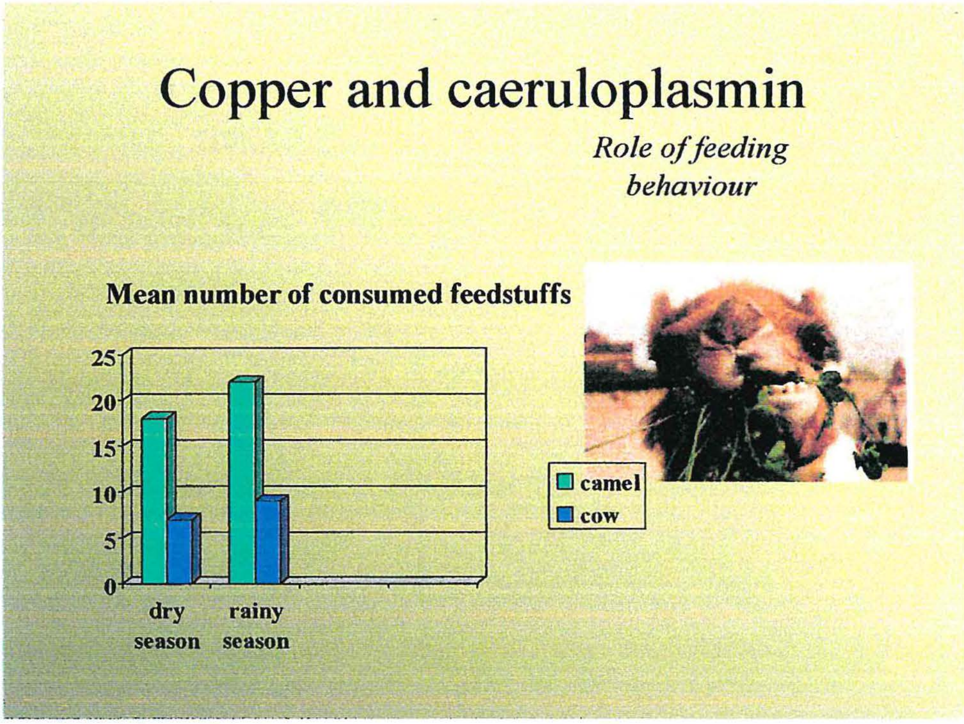
(Djibouti, India)

Copper deficiency

No clear cases of sway back

- Description of a « sway disease » in China on Bactrian camel
- Non specific troubles in camel at Djibouti with very low copper in plasma (5 µg/100ml)


Copper and caeruloplasmin
In µg/100ml
140
120
100
80
60
40
20
0
1
48
94
195
Période de complémentation
cam
cow
83 Moty et al, 1968 Egypt
95,3 Tartour, 1975 Sudan
88,7 Idris et al, 1980 Sudan
92,6 AbuDamir et al,1983 Sudan
107 Faye et al, 1986 Ethiopia
118,3 Wahbi et al, 1979 Sudan
126,5 Marx et Abdi,1983 Somalia
75 Abdalla et al, 1988 Emirates
76,5 Eltohamy et al, 1986 Egypt
65 El Kasmi, 1989 Morocco
60,7 Faye et Mulato, 1991 Djibouti
65,4 Faye et al, 1995 France
102 Bengoumi et al, 1995 Morocco
94,3 Ghosal et al, 1992 India
86 Liu et al, 1994 China*
80,4 Ma Zhuo, 1995 China*
Field results
Experimental results


Copper and caeruloplasmin
Role of feeding behaviour
Mean number of consumed feedstuffs
25
20
15
10
5
0
dry season
rainy season
camel
cow

Copper and caeruloplasmin

Apparent absorption rate (in case of no supplementation):

camel 75-80%

cow 85-86%

Apparent absorption rate with supplementation:

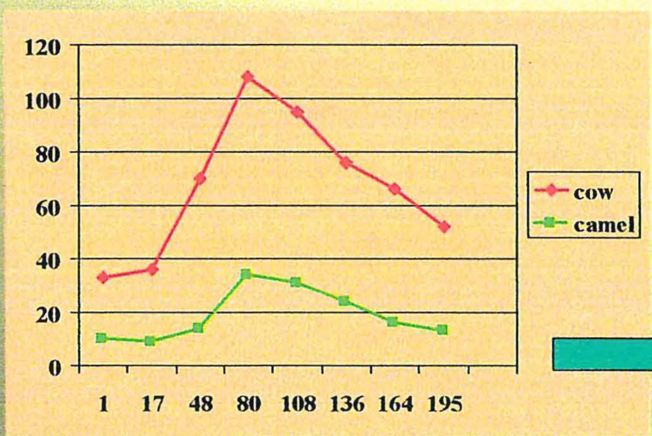
camel 65 %

cow 61%

Lower requirements but better storage in case of favourable situation

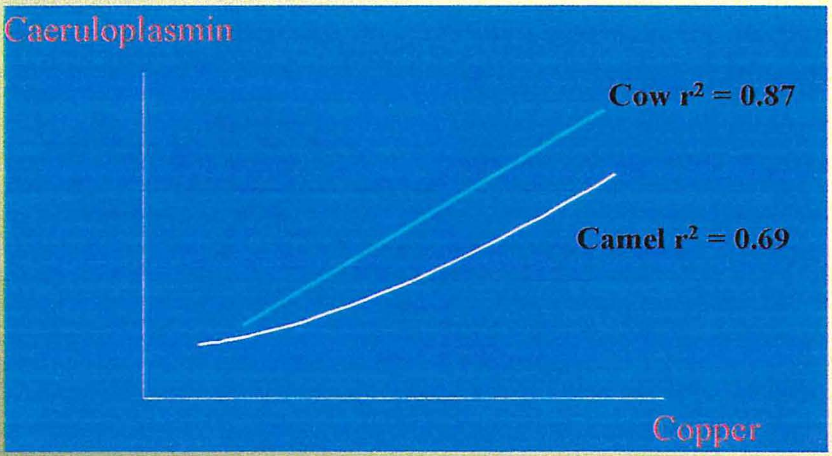
Copper and caeruloplasmin

Liver storage (in mg/kg DM)



Lower copper requirements??

Copper and caeruloplasmin



Maintenance of metabolic activities in case of deficiency

Caeruloplasmin

Purification of Camel Caeruloplasmin

There are no clear differences in the physico-chemical parameters of camel Cp as compared to other mammals Cp. Besides, the trace element metabolism in camel indicates that this animal is able to assume its intracellular enzymatic function in spite of reduced copper concentration in the diet, **Cp cannot be the sole protein implied in this particular metabolism**. Further proteins, such as albumin, or other biological structures (amino acids, hormones..) contributed certainly to this regulation. **Other questions remain unanswered, particularly the homogeneous, compact and acid properties of camel Cp.**

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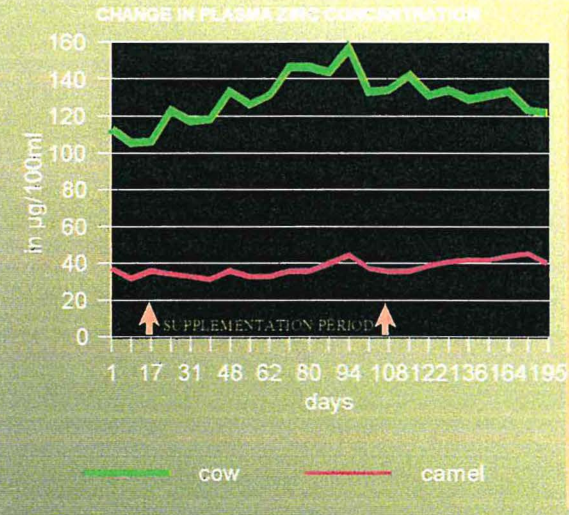
Zinc deficiency

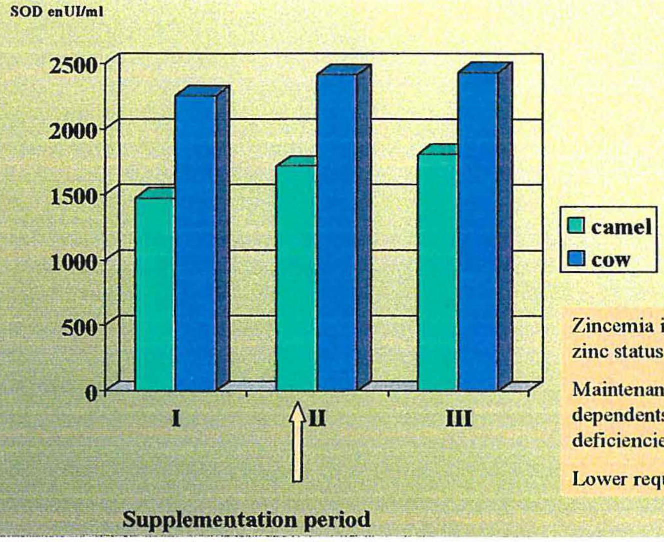
- No clear description of zinc deficiency
- Question about the threshold limit of zinc deficiency by assessment of plasma zinc rate
- Relationships with skin diseases common in camel

Zinc and superoxid dismutase



135+ 4,1 Egypt	Moty et al, 1968
100,4+ 21 Ethiopia	Faye et al, 1986
118,3+ 28,8 Sudan	Wahbi et al, 1979
41 + 5 Emirates	Abdalla et al, 1988
93,4+ 4,2 Egypt	Eltohamy et al, 1986
107+ 36 Morocco	El Kasmi, 1989
46,2+ 17,2 Djibouti	Faye et Mulato, 1991
85,4+ 2,5 India	Ghosal et al, 1992
101+ 4,1 India	Singh et al, 1994
34,6+ 7,8 France	Faye et al, 1995
34+ 7 Morocco	Bengoumi et al, 1995

Zinc and superoxid dismutase



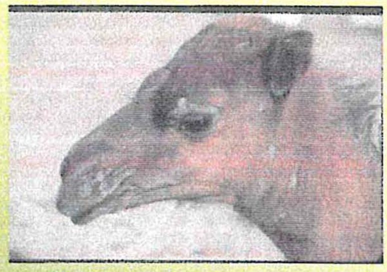
Zincemia is not a good indicator of zinc status

Maintenance of the zinc-dependents activities in case of deficiencies

Lower requirements ?

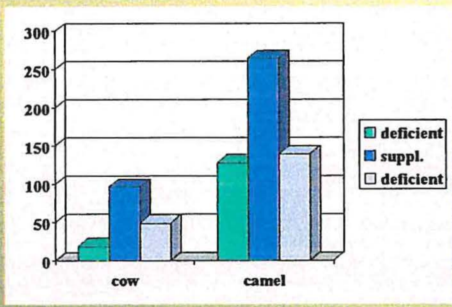
Zinc

- Relationships between zinc status and skin diseases??
- Relationships between zinc status and immunity??
- Relationships between zinc status and calf mortality???



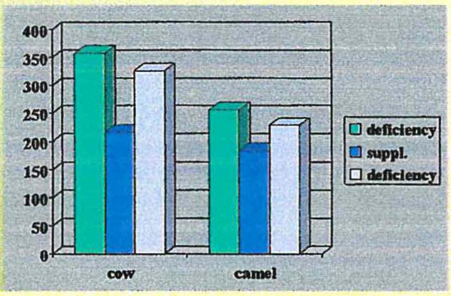
Iron and manganese

Apparent absorption rate in mg/d/100kg de LW



Manganese

Iron



Better absorption of Mn but not in iron except in case of supplémentation

Selenium in camel

Status	ng/ml Se
No pregnant (n=56)	[a]138±47
Pregnant (n=69)	[b]281±9
Milking (n=29)	[b]282±11

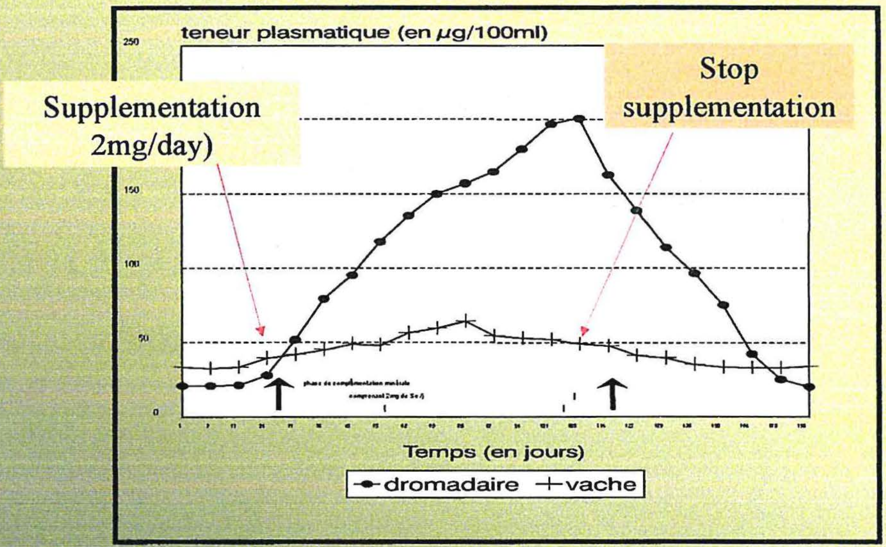
White muscle disease

Selenium in camel

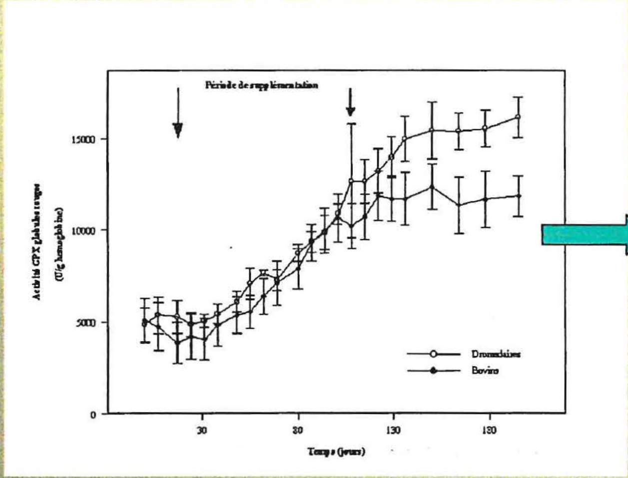
Age	ng/ml Se
3-4 y n=104	[a]142 ±43
5-7 y n=98	[b]281 ±7
>8 n=38	[b] 129± 8

Sexe	ml/ng Se
Male n=86	[a]139±5
Female n=154	[b]229 ±7

Selenium and glutathion-peroxidase



Selenium and glutathion-peroxidase



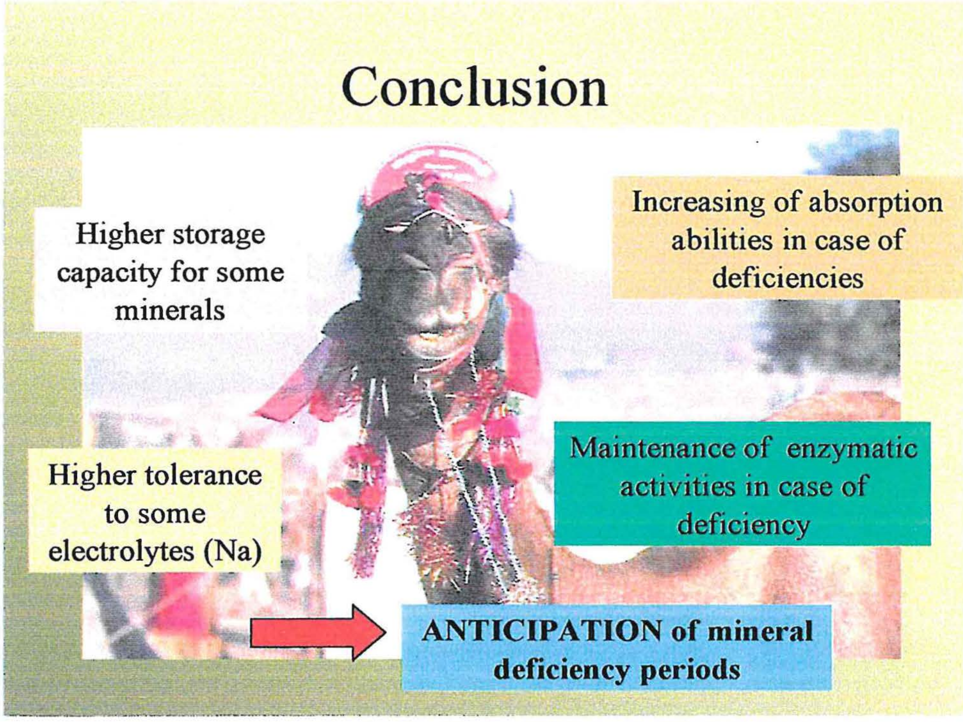
"Storage" of selenium

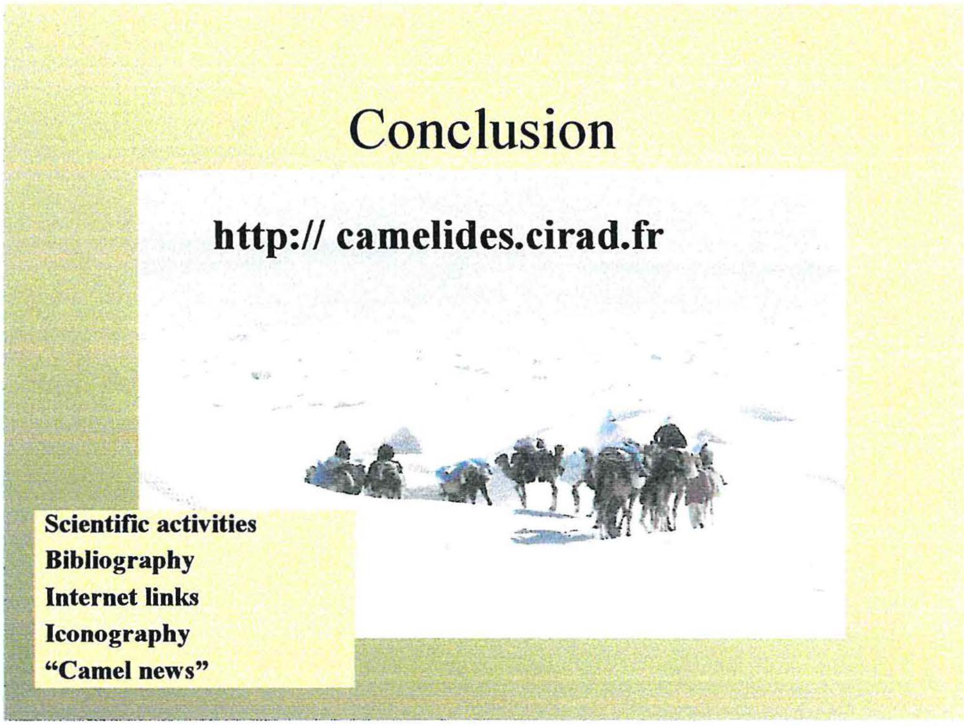
maintenance of enzymatic activities (life cycle of RBC)

Role of Se-Prot.

Other minerals

- Cobalt deficiency poorly described in Mongolia on Bactrian camel
- Iodine deficiency reported in Sudan (Darfour area)
- Fluoride and sulphur intoxication reported in Egypt
- Heavy metals contamination in Kazakhstan (lead, cadnium, chrome…)


Conclusion
Higher storage capacity for some minerals
Increasing of absorption abilities in case of deficiencies
Higher tolerance to some electrolytes (Na)
Maintenance of enzymatic activities in case of deficiency
ANTICIPATION of mineral deficiency periods


Conclusion
http:// camelides.cirad.fr
Scientific activities
Bibliography
Internet links
Iconography
"Camel news"

ANNEXE 6

Protocole expérimental d'intolérance au sélénium

Protocole expérimental d'intolérance au sélénium

Hypothèse :

Le dromadaire montre une réactivité très forte à la complémentation en sélénium par voie orale qui se traduit par une augmentation importante de sa sélénémie. Cependant la tolérance au sélénium est mal connue. Sachant que chez les chevaux et autres herbivores, la limite de tolérance est estimée à 2-5 mg/kg de ration selon le type de fourrages ingérés, il est envisagé de travailler sur 3 niveaux élevés de sélénium, respectivement à la limite, légèrement au-dessus et largement au-dessus de la limite hypothétique de tolérance.

Les animaux d'expérimentation seront des individus âgés de deux environ pesant entre 150 et 200kg. La quantité ingérée est de l'ordre de 2kg de MS/100kg de PV, soit au maximum 4kg de MS ce qui, compte tenu de la ration (foin + concentrés) représente environ 5kg de ration fraîche. On peut donc estimer la limite de tolérance autour de 10mg de Sélénium.

Protocole expérimental :

Durée de l'essai : deux mois
6 animaux âgés de 2 ans maximum.
3 lots de 2 animaux :
- Lot 1 : reçoit 10 mg de sélénium par jour pendant 30 jours
- Lot 2 : reçoit 14 mg/j de sélénium pendant 30 jours
- Lot 3 : reçoit 18 mg/j de sélénium pendant 30 jours

Calendrier des prélèvements de sang : J1, J15, J30, J45, J60
+ prélèvements au moment de l'apparition de symptômes si le cas se présente
+ autopsie en cas de mortalité

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ANNEXE 7

Article proposé pour la revue Al-Asail (« race pure »)

Article proposé pour la revue Al-Asail (« race pure »)

The selenium in racing camel: the challenges for a good balance

B. Faye, R. Seboussi, G. Alhadrami

The minerals are a part of the feeding resources essential for the animal life. The deficiency can occur even in the desert where the minerals are a dominant element in the landscape. So, the camel can be affected by mineral deficiency or in some occasions by mineral toxicity. Some minerals are necessary in high quantity for the general metabolism and body structure (calcium, phosphorus, potassium, sodium, magnesium), other minerals play an essential role for enzymes activities in general metabolism of the animals, but the requirements are in very low quantity (copper, zinc, manganese, iron, iodine, cobalt and so on). Selenium is one of these elements. It enters in the composition of an enzyme (glutathione-peroxidase) which plays a central action in the cell protection by anti-oxidative activity. Many studies in domestic animals have shown that selenium supply is linked to a better immune system by the protection of the cells involving in immunity process (white blood cells). Selenium is also involved in reproduction performance and in muscle metabolism. A lack of selenium can lead to infertility, muscle degenerative and heart failure.

Selenium deficiency is common in some places of the world where selenium is in low quantity in soils and plants. Such situation is generally more common in arid areas. In Emirates, selenium deficiency in camel is regularly observed because soil and plant deficiency. For example, almost 25% of the camel calf mortality cases reported in Veterinary Laboratory at Al-Ain could be attributed to heart muscle dystrophy which is the main symptom of selenium deficiency in young animals. The muscle degenerative impact of the lack of selenium can have a high consequence on the muscle activity and especially on race animals where this activity is strongly requested.

Unfortunately, if the requirements for cattle, sheep, goat and horse are well known, we have very few informations concerning selenium requirements for camel in general and camel race in particular. There is little evidence to date of clinical deficiencies. Only a few results on plasma or blood values in field conditions in different areas from Morocco, China, Saudi Arabia or in some zoological parks are available in the literature. Selenium deficiency has been observed also in young camels with temperate feeding conditions in France. Some data have been collected recently in Emirates.

However, if blood and organ references are available in camel, the metabolism of selenium in that species is quite unknown. In the main cases, farmers and owners of race camels applied the recommendations given for cattle. This practice could be debatable. Indeed, in an experiment, achieved in Morocco, comparing cow and camel where similar selenium supplementation supplied animals (with 2mg/day for 2 months which is the double dose generally proposed for cattle), it has been observed a strong higher increasing of plasma selenium in camel (10 times the blood level before supplementation) than in cow (2 times). It has been concluded that plasma selenium level was a very sensitive indicator of oral selenium supply in camel. But, it was not possible to confirm if there is a specific sensitivity of camel to selenium deficiency or toxicity. Indeed, the selenium depletion was also faster in the above mentioned trial. After one month without supplementation, the plasma selenium level returned to "normal". It seemed to indicate a better efficiency of selenium absorption and excretion in camel compared to cattle. From this observation, many questions appear.

Indeed, one important aspect in race camel is the selenium supply. As it is considered that selenium is beneficial for muscle activity, selenium supplementation is very common in racing camel farms. Now, the limit between selenium requirements and selenium toxicity could be very narrow in camel according to the previous observation. In Emirates, it has been observed that muscle discolouration occurs in 2 years-camel after 8 mg daily selenium supplementation for 2 months (see photo). However, there are no references on selenium toxicity in camel. We do not know in fact the risk of an important supplementation on muscle activity and we do not know the way of selenium excretion and storage in camel. So, what exact proposal can be done to the camel farmers?

To answer to this question, a research project started at the Emirates University (Pr. ALHADRAMI) in collaboration with CIRAD (Dr FAYE), a French Research Institute, and the contribution of the veterinary laboratory from Agricultural department, and laboratory of Cheikh Khalifa Ben Zayed Al Nehiyan. This project achieved in the frame of sandwich PhD (Dr SEBOUSSI) involving the both partners and supported by the French Embassy at Abu Dhabi aims to evaluate the selenium requirements and possible toxicity in racing camel. Several experiments are currently performed. In these trials, selenium intake is strictly measured as well as the different excretion way (milk, urine, faeces), both in adult camel, pregnant or lactating, in suckling calf, in non lactating camel (see photos). Trials to evaluate toxicity level are also achieved in young camel.

Through these current experiments, we expect to answer to the main questions of the selenium balance in racing camel, both to avoid the deficiency and the toxicity for an optimal use of selenium supplementation.