

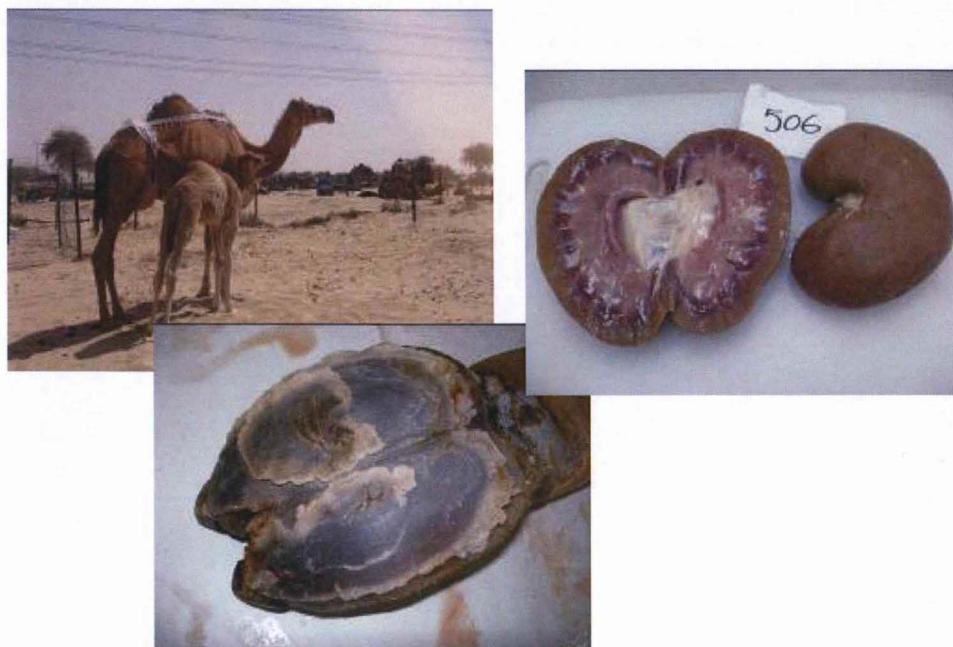


MISSION D'APPUI A LA THESE DE Rabiha SEBOUSSI

(EMIRATS ARABES UNIS)

« Métabolisme du Sélénium chez le dromadaire »

du 6 au 14 novembre 2007



Bernard FAYE



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RÉSUMÉ :

Cette mission visait l'appui scientifique à la thèse de Mlle SEBOUSSI, inscrite à l'Université de Montpellier II et dont j'assume la direction de la thèse à Sup'Agro en partenariat avec le Dr AL-HADRAMI de l'université d'Al Ain. Au cours de cette mission, les expérimentations étant terminées, il a été mis en œuvre le traitement statistique des données des expérimentations et le début de rédaction des articles scientifiques. La soutenance doit se tenir à Montpellier en avril 2008.

En marge de cette mission, les discussions à propos de l'ISOCARD (Société Internationale de Recherche et Développement des camélidés) ont également eu lieu avec le Dr AL-HADRAMI, secrétaire de cette association dont j'assume la présidence depuis avril 2006 (publication du premier numéro on-line de *Journal of Camelid Sciences*, revue de l'ISOCARD, développement du site web www.isocard.org, organisation de la prochaine conférence internationale à Djerba en 2009, projet de création du « camelpedia »). Les propositions 2008 ont été faites au Service de Coopération de l'Ambassade de France. Plusieurs projets de thèse sont à l'étude ainsi qu'un séjour d'un mois comme Professeur d'Université.

SOMMAIRE

Résumé

Remerciements

1 - Introduction	1
2 - Rapport d'avancement de la thèse	1
3 - Propositions pour la poursuite de la coopération	3
3-1. Stage Master au Laboratoire Vétérinaire	3
3-2. Supervision d'un nouveau travail de thèse	3
3-2. Séjour prolongé à l'Université	3
4 - L'ISOCARD	3
5 - Conclusion	4

ANNEXES

ANNEXE 1 - Calendrier de la mission et personnalités rencontrées	7
ANNEXE 2 - Questionnaire destiné aux candidats de la prochaine conférence de l'ISOCARD	11
ANNEXE 3 - Proposition de fiche de stage 2007	17
ANNEXE 4 - Contenu et avant-propos du premier numéro du « Journal of camelid Sciences »	21
ANNEXE 5 - Sommaire du « camelpedia »	27
ANNEXE 6 - Article soumis à BTER	31

RESUME

Cette mission visait l'appui scientifique à la thèse de Mlle SEBOUSSI, inscrite à l'Université de Montpellier II et dont j'assure la direction de sa thèse à Sup'Agro, en partenariat avec le Dr AL-HADRAMI de l'Université d'Al Ain. Au cours de cette mission, les expérimentations étant terminées, il a été mis en œuvre le traitement statistique des données des expérimentations et le début de rédaction des articles scientifiques.

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REMERCIEMENTS

J'adresse mes sincères remerciements au Dr ALHADRAMI, désormais Doyen du « Food and agriculture college d'Al-Ain » pour son accueil et sa motivation toujours aussi forte.

Merci aussi à R. SEBOUSSI pour sa grande disponibilité et motivation. Je tiens à remercier le service de Coopération de l'Ambassade de France qui s'est montré particulièrement intéressé par cette collaboration sur les grands camélidés et qui apparaît toujours aussi déterminé à soutenir les actions de coopération avec l'Université des Emirats Arabes Unis.

1 - INTRODUCTION

On rappellera en introduction que cette mission appuyée par le Service de Coopération de 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 est focalisée actuellement sur la biologie des camélidés et la thèse de Rabiha SEBOUSSI (inscrite à Montpellier II via Sup'Agro et conjointement à l'Université d'Al-Ain).

Cette mission était rendue nécessaire, la thèse de Mle SEBOUSSI étant dans sa phase de traitement des données et de pré-rédaction de sa thèse dont la soutenance est espérée au premier semestre 2008. Cette mission visait aussi à approfondir avec le Pr. Al-Hadrami, désormais Doyen, les activités futures de l'ISOCARD (*International Society of Camelid Research and Development*), créée lors de mon passage en avril 2006 au cours de la première conférence internationale. Je rappelle ici que j'assume la présidence de l'ISOCARD, le Pr. Al-HADRAMI assurant le secrétariat.

2 - RAPPORT D'AVANCEMENT DE LA THESE

Le sujet porte sur le métabolisme du Sélénum, élément minéral présent à l'état de trace dans les organismes vivants mais essentiel dans un certain nombre de fonctions biologiques. Le sélénum est crucial pour ses propriétés anti-oxydatives tout comme d'autres éléments comme la vitamine E, le betacarotène, l'ascorbate, la glutathion-peroxydase (GPx) et d'autres éléments traces comme le cuivre et le zinc. Ces paramètres jouent un rôle crucial dans la protection des tissus de l'organisme contre la destruction oxydative induite par les stress physiologiques et pathologiques auxquels les animaux et tout particulièrement le dromadaire sont exposés.

Les études sur le statut des antioxydants chez le dromadaire sont rares et fragmentées. Il existe à l'heure actuelle, à peine une dizaine de références sérieuses publiées sur le sujet. L'objectif dans ce présent travail de thèse est :

1. d'évaluer le niveau du sélénum chez cette espèce,
2. d'explorer le métabolisme du sélénum du dromadaire pour couvrir ses besoins physiologiques de maintien, de reproduction et de performance,
3. d'étudier sa toxicité, ses manifestations cliniques pour évaluer enfin les seuils toxiques ce qui permettra de déterminer les limites d'utilisation des suppléments alimentaires largement distribués dans les pays du Golfe,
4. de mieux cerner les dangers représentés par l'utilisation anarchique du sélénum dont la toxicité est importante.

Pour réaliser ces objectifs, 4 expérimentations ont été mises en place à la ferme d'El-Foha appartenant à l'Université d'Al-Ain :

- Expérimentation n°1 : Effet de différents niveaux de complémentation en Sélénum sur le statut minéral sanguin
- Expérimentation n°2 : Effet de la complémentation en sélénum sur l'excrétion fécale, lactée et urinaire chez la chameau gestante et lactante
- Expérimentation n°3 : statut en sélénum des organes du dromadaire
- Expérimentation n°4 : tolérance au sélénum chez le chameau de un an.

Le travail de thèse en est à sa phase finale avec les éléments suivants à considérer :

- ◆ une inscription en 4ème année a été demandée et obtenue auprès de l'Université Montpellier II en arguant du fait qu'une des expérimentations était réalisée sur des chameaux dont on devait s'assurer la gestation ; or, celle-ci durant 13 mois, le délai d'attente pour la mise en place des essais (qui portaient sur des chameaux en fin de gestation et en début de lactation) devenait peu compatible avec les exigences de la durée normale d'une thèse ;
- ◆ les analyses les plus centrales du travail (sélénum sérique, glutathion peroxydase - GPx-Se-, intra-erythrocytaire, vitamine E) n'ont pu être mises en œuvre que très tardivement pour les raisons expliquées dans le précédent rapport (absence de standards internationaux, difficulté à se procurer sur place les kits de dosage de la GPx-Se), et donc les analyses de données finales ont pu être entamées qu'au cours de la présente mission ;
- ◆ les bases de données sont maintenant complètes et organisées sous Access ce qui a pu se réaliser suite à la formation suivie par R. SEBOUSSI en octobre 2005 au CIRAD-EMVT (formation gestion et traitement des données zootechniques et sanitaires) ;
- ◆ les procédures répétitives (construction des tableaux de données, analyses de variance et calcul des corrélations entre paramètres) sont établies depuis l'an dernier mais sont désormais opérationnelles ;
- ◆ le canevas de 3 publications est rédigé et il suffit désormais de rajouter les résultats et la discussion pour soumettre ces articles à plusieurs journaux.

Autrement dit, le travail de thèse se situe aujourd'hui à une phase cruciale du traitement final des données ce qui devrait prendre peu de temps, et surtout de rédaction finale des articles et de la thèse et qui devrait pouvoir se réaliser pour une soutenance prévue au plus tard en avril 2008.

Au cours de la mission, il a été procédé à l'analyse finales des données (statistiques descriptives, corrélations entre les variables, analyse de variance sur données répétées et accessoirement analyse en composantes principales et classification hiérarchique). Tous les résultats sont désormais disponibles ou presque. Plusieurs articles sont également en cours de rédaction.

Pour l'instant les travaux de thèse ont pu permettre de rédiger quelques publications :

1. 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. SEBOUSSI R., FAYE B., ALHADRAMI G., 2004. Facteurs de variation de quelques éléments trace (sélénum, cuivre, zinc) et d'enzymes témoins de la souffrance musculaire (CPK, ALT et AST) dans le sérum du dromadaire (*Camelus dromedarius*) aux Emirats Arabes Unis. *Rev. Elev. Med. Vét. Pays Trop.*, 57 (1-2), 87-9
3. SEBOUSSI R., ALHADRAMI G., FAYE B., ASFOUR T., ELKHOULY A., ALBELKHALEK T., ALMASRI J., 2006. Effect of age, sex, breed and physiological status on selenium (Se), copper (Cu), zinc (Zn) and enzymes indicators of muscular fatigue in dromedary (*Camelus dromedarius*). Proc. 1st Intl Conf. of the International Society of Camelid Research and Development (ISOCARD), Al-Ain, 15-17 April 2006, United Arab Emirates, Poster n°66.
4. SEBOUSSI R., FAYE B., AL-HADRAMI G., ALKHOULY A., MOHAMED T., ASKAR M., HACEN K., 2007. Selenium toxicity on camel. Proc. Intl. Wokshop « Impact of pollution on livestock », B. Faye and Y. Syniavskiy Eds., Springer Publ., NATO series, Almaty (Kazakhstan)?

Plusieurs autres publications sont donc prévues dans un laps de temps court. Il s'agit dans un premier temps de :

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

Un document de synthèse à visée opérationnelle est également envisagé.

Enfin, au cours de la mission, il a été discuté de la composition du jury. Ont été évoqués les noms de François MESCHY, Professeur à l'INAPG et spécialiste des minéraux chez les ruminants, J.F. GRONGNET, Professeur de zootechnie à l'ENSA de Rennes, Mme Josyane ARNAUD, spécialiste du sélénium à l'INSERM et un chercheur INRA à identifier.

3 - PROPOSITIONS POUR LA POURSUITE DE LA COOPERATION

3-1 - Stage Master au Laboratoire vétérinaire

Ce stage avait été prévu en 2006 pour un étudiant du Master PARC de l'Université de Montpellier (profil vétérinaire, mais aucun stagiaire n'a pu être identifié. Cela consiste à mettre en œuvre un travail de conception de fiches « maladies du dromadaire » à partir de cas clinique et d'études épidémiologiques s'appuyant sur des photos de lésions (y compris sur des données histopathologiques) et un descriptif des cas répertoriés. La fiche de stage est rappelée en annexe. Ces fiches pourront être les premiers éléments d'une « camelpédia » en ligne disponible sur le site web de l'ISOCARD (voir plus loin). Le directeur du laboratoire (Dr Tarik ASFOUR s'est montré favorable à cette initiative).

3-2. - Supervision d'un nouveau travail de thèse

Une demande a été formulée auprès du Pr. AL-HADRAMI désormais Doyen du collège « Food and agriculture ». Comme signalé dans mon précédent rapport 2006, j'ai été sollicité pour des demandes de supervision de thèse universitaire par des ressortissants des Emirats (nationaux ou étrangers), mais la maîtrise du français est plutôt rare parmi les étudiants et étudiantes de l'Université à Al-Ain. Toutefois, on peut envisager des inscriptions dans d'autres universités de langue anglaise. Plusieurs projets portant sur le lait de chameau ou la biologie du dromadaire sont à l'étude.

3-3. - Séjour prolongé à l'Université

Le Doyen du collège « Food and agriculture » propose ma participation à l'organisation d'une session de cours sur une période d'un ou deux mois, proposition qui peut effectivement m'intéresser sous réserve des conditions octroyées. Les contacts doivent être repris prochainement pour en discuter des modalités.

4 - L'ISOCARD

Issue de la conférence internationale tenue à Al-Ain en avril 2006, l'ISOCARD (International Society of Camelid Research and Development) dont j'assume la présidence (notre partenaire le Pr. AL-HADRAMI, Doyen du collège « Food and Agriculture » en assurant le secrétariat) a engagé plusieurs actions afin de structurer la communauté scientifique des camélologues. Nous pouvons citer entre autres les actions suivantes :

- mise en place d'un site web fonctionnel (www.isocard.net) comprenant notamment la liste de tous les membres adhérents (environ 180 à ce jour), les résumés des interventions de la conférence d'avril et une rubrique « le who's who in camel sciences » ;
- préparation de la prochaine conférence qui se tiendra en mars 2009 à Djerba (Tunisie) suite à la décision du Comité exécutif. Une réunion de ce comité devra d'ailleurs se tenir à Djerba en mars prochain pour définir les différents points d'organisation de la conférence ;
- la création effective d'un International Journal of Camelid Sciences en ligne devant contenir, entre autres, les présentations aux conférences de l'ISOCARD (on trouvera en annexe le contenu du premier numéro qui devrait sortir dans quelques semaines) ;
- la publication d'une plaquette de présentation de l'ISOCARD ;
- le lancement d'une « camelpedia », sorte d'encyclopédie libre sur les camélidés dont on trouvera le sommaire en annexe ;
- un travail de sponsoring a été entamé ce qui a permis de disposer déjà d'une petite mise de fond sur le compte de l'ISOCARD

5 - CONCLUSION

On ne peut que répéter ici ce que j'avais écrit dans un rapport précédent, à savoir que la coopération entre le CIRAD et l'Université des Emirats demeure modeste mais reste bien soutenue par le Service de Coopération de l'Ambassade de France en dépit des restrictions budgétaires qui en limitent la portée. Les Emirats ne faisant pas partie de la zone de solidarité prioritaire, on ne peut espérer aller plus loin qu'avec un appui similaire des partenaires émiriens. C'est ce à quoi, nous essayons de parvenir au travers notamment de la création de l'ISOCARD.

Compte tenu des suggestions du présent rapport, on trouvera ci-après les propositions pour 2008, étant bien entendu qu'il s'agit là d'une proposition optimale selon les ordres de priorité :

- | |
|--|
| <ul style="list-style-type: none"> ➔ une bourse d'un mois pour R. SEBOUSSI en avril 2007 à Montpellier pour sa soutenance de thèse ➔ une mission d'appui pour la phase finale de rédaction de la thèse courant février 2008 d'une dizaine de jours (voyage + per diem) ➔ un appui si possible pour la participation du Pr. AL-HADRAMI à la soutenance de thèse en tant que co-supervisor de la thèse de R. SEBOUSSI ➔ un appui administratif pour un stage d'un étudiant du master PARC (si un billet d'avion peut être pris en charge, ce serait optimal) |
|--|

ANNEXES

ANNEXE 1 - Calendrier de la mission et personnalités rencontrées

ANNEXE 2 - Questionnaire destiné aux candidats de la prochaine conférence de l'ISOCARD

ANNEXE 3 - Proposition de fiche de stage 2007

ANNEXE 4 - Contenu et avant-propos du premier numéro du « Journal of Camelid Sciences »

ANNEXE 5 - Sommaire du « Camelpedia »

ANNEXE 6 - Article soumis à BTER

ANNEXE 1

Calendrier de la mission et personnalités rencontrées

Calendrier de la mission et personnalités rencontrées

Mardi 6 novembre

- Départ de Montpellier
- Arrivée à Al-Ain via Dubaï

Mercredi 7 novembre

- Entretien avec le Pr. AL-HADRAMI, Doyen de la faculté, à l'Université
- Entretien avec Dr TARIK, directeur du Laboratoire Vétérinaire
- Entretien avec le Dr WISSAM IBRAHIM (Département de nutrition et santé)
- Première séance de travail avec R. SEBOUSSI

Jeudi 8 novembre

- Départ pour Abu Dhabi
 - Entretien avec M. Didier GAZAGNADOU, Conseiller de Coopération au SCAC d'Abu-Dhabi, et Mme Marjane MASHKOUR, Chargée de recherches au CNRS
- Retour sur Al-Ain
 - Traitement des données de l'expérimentation 1

Vendredi 9 novembre

- Poursuite des analyses de données de l'expérimentation 1

Samedi 10 novembre

- Rédaction de l'article pour *Biological trace Element Research* (expérimentation 1)

Dimanche 11 novembre

- Poursuite de la rédaction de l'article et préparation des données de l'expérimentation 2.

Lundi 12 novembre

- Traitement des données des expérimentations 2, 3 et 4

Mardi 13 novembre

- Visite de la ferme cameline laitière de M. Ali AL-ATAIRY avec Louis LALEYE, professeur à l'Université.
- Fin du traitement des données
- Entretien avec le Dr WISSAM (département Health and Nutrition)
- Entretien avec M. Boubacar JOBE, Professeur.

Mercredi 14 novembre

- Départ pour Dubaï et Montpellier via Paris

ANNEXE 2

Questionnaire destiné aux candidats de la prochaine
conférence de l'ISOCARD



INTERNATIONAL SOCIETY OF CAMELID RESEARCH AND DEVELOPMENT

Dear Colleagues,

At the General Assembly of ISOCARD at Al-ain on April 15th 2006, you volunteered to organize and host the second conference in 2009. Since there were several other volunteer host countries, the executive board has decided to send each candidate country a small questionnaire. This will help us to decide the place and the date of this important event for the camelid scientist international community.

Please could you send us your responses before December 15th 2006 in order to be considered. A final decision about who will have the support of the Society for this event will be made in March 2007 by the executive board of ISOCARD at a meeting to be held at Montpellier, France. Please note that no applications will be accepted after this date.

Please send your answers to the Chairman of the Board at the address below.

I thank you in advance for your valuable contribution to the promotion of camelid sciences throughout the world.

Dr Bernard FAYE
Chairman of ISOCARD

Main office: UAE university
PO Box n° 17555
Al-Ain, United Arab Emirates

Chairman Office: CIRAD-EMVT TA 30/A
Campus International de Baillarguet
34398 – Montpellier Cedex (France)

Second conference of ISOCARD 2009

Application form for candidacy

COUNTRY of applicant :

TOWN at which the conference will be held:

Organizer

➤ Name and address of the institution:

- address
- Tel/fax
- email

➤ Name and full address of the coordinator :

- address
- Tel/fax
- email

➤ Name of the co-organizer:

- address
- Tel/fax
- email

Proposed date in 2009:

Local support expected (give the names and location):

- universities and research institute:
- administrative authorities:
- local or national development agencies:

Sponsor support expected:

- Veterinary laboratories:
- Others (give the name):

Have you already organized international meeting on camel sciences or others (give the names) ?

- 1.
- 2.
- 3.

....

Hotel accommodation in the town where the conference will be organized (give some details on the accommodation facilities):

Transportation:

- Accessibility of location
- flight companies travelling to location:
- what transportation is available to reach location and projected cost:
- if transportation will be provided for delegates free of charge or at what cost

What social activities do you envisage planning?

With conference attendees travelling long distances to attend the conference, they will most likely enjoy being able to see some local culture or taking part in an activity that allows them to see an interesting aspect of Camelid production in your country. What ideas do you have for meeting this possibility?

Do you expect to be able to provide any financial support for individuals coming from developing nations in order to encourage them to attend?

ISOCARD is non-political and non-discriminatory with regard to race, religion and gender. Please provide assurances that all people will be fully welcomed at the conference and that no exclusions will be made from conference areas etc.

What support do you expect from ISOCARD?

Applicants for 2009

Dr Touhami Korchani, Institut de Régions Arides, Médenine, Tunisie
Khorchani.Touhami@ira.rnrt.tn

Dr Mohammed Bengoumi, Institut Agro-vétérinaire Hassan II, Rabat, Maroc
m.bengoumi@jav.ac.ma

Pr Ali Mohamed AbdelMajid, National Center for research, Khartoum, Sudan
ali.alimajid@gmail.com

Dr Sheick Awad Abdelrahim, Arasco, Riyadh, Saudi Arabia
Sheick@arasco.com

ANNEXE 3

Proposition de fiche de stage 2007

PROPOSITION DE STAGE

CEAV « Pathologies animales en RC » ou Master PARC

Lieu de stage (place)	Laboratoire vétérinaire d'Al-Ain/Université d'Al-Ain (Emirats Arabes Unis)
Sujet du stage	Suivi des cas de pathologies cliniques chez le dromadaire dans les différentes cliniques vétérinaires des Emirats Arabes Unis et réalisation de fiches didactiques pour un site web.
Problématique et contexte du stage	La Société Internationale de recherche et Développement chez les Camélidés (ISOCARD en anglais) a été fondée récemment aux Emirats Arabes Unis avec un objectif de renforcement des liens au sein de la communauté scientifique internationale des camélogues. L'une des activités en projet est la mise en place d'une encyclopédie en freeware sur les camélidés (camelpedia) dont le lancement sera assuré par l'édition de fiches sur les maladies du dromadaire pour lesquels il n'existe que des ouvrages généralistes.
Programme proposé et déroulement du stage	<ol style="list-style-type: none"> 1. Suivi des cas cliniques et des troubles sanitaires dans les cliniques vétérinaires camélines assez nombreuses dans les Emirats Arabes Unis 2. Analyses complémentaires (bactériologie, virologie, biochimie, histologie) en cas de besoin 3. Photographie des lésions et analyse épidémiologique en cas de besoin 4. Rédaction des fiches didactiques par maladie ou cas cliniques
Durée et date de départ souhaitée	D'avril à Août
Cadre institutionnel	<p>Structure d'accueil: Université d'Al-Ain (collège d'alimentation et d'agriculture)/ Laboratoire Central Vétérinaire</p> <p>Maître(s) de stage (nom et fonction):</p> <ul style="list-style-type: none"> - G. ALHADRAMI, doyen du collège - Dr A. TARIK, directeur du laboratoire <p>Signataire de la Convention de stage (nom et fonction):</p> <ul style="list-style-type: none"> - G. ALHADRAMI, doyen
	<p>Contact sur le terrain (nom et e-mail): hadrami@uaeu.ac.ae (Pr Alhadrami) tqasfour@gmail.com (Dr Tarik)</p> <p>Tuteur en France (nom et e-mail) : Bernard FAYE, Chargé de mission ressources Animales faye@cirad.fr</p>
Remarques et conditions particulières (diplôme requis, langues pratiquées, aptitudes particulières)	<p>Anglais obligatoire</p> <p>Nationalité française (dans le cadre de la coopération bilatérale Franco-Emirats)</p> <p>Formation vétérinaire</p> <p>Stage plutôt déconseillé aux femmes compte tenu du contexte socioculturel</p>
Conditions matérielles	<p>Voyage (Air ticket) : pris en charge par l'étudiant</p> <p>Logement et logistique: Pris en charge par l'Université</p> <p>Travail de terrain: pris en charge par le laboratoire</p> <p>Indemnités de stage : à discuter localement</p>

ANNEXE 4

**Contenu et avant-propos du premier numéro
du « Journal of Camelid Sciences »**

Issue n°1

September 2007

JOURNAL OF CAMELID SCIENCES

- On-line review -



**INTERNATIONAL SOCIETY OF CAMELID RESEARCH
AND DEVELOPMENT**

CONTENT

RESOURCES

Evaluation of the range plants quality and palatability for camel grazing in the United Arab Emirates.

Kamal Hussien Shaltout, Ali Ali El Keblawy and Mohamed Taher Mousa

PHYSIOLOGY

Effect of some physical factors on serum levels of calcium, phosphorus and magnesium in camels in Upper Egypt

Abd-El-Salam M.N., Mottelib A.A., Ismail M.N. and Mohammed A.A.

Parathyroid hormone-related peptide stimulates intestinal strontium absorption in Camels (*Camelus dromedarius*)

El Khasmi Mohammed, Riad Fouad, Safwate Abdallah, Farh Mohamed, El Abbadi Najia, Davicco Marie Jeanne, Coxam Véronique and Faye Bernard

PHARMACOLOGY

Tolerance study of Tiludronate in dromedary camel

Mohammed Bengoumi

PRODUCTIONS

Camels (*Camelus dromedarius*) under pastoral systems in North Kordofan, Sudan

Seasonal and parity effects on milk composition

Sallam A. Bakheit, Ali M. AlMajid and Abdel Moneim M. AlNikhala

A Good Milkable Camel Udder

Carl Edward Archibald Albrecht

Meat Quality and Composition of *Longissimus thoracis* from Arabian Camel (*Camelus dromedaries*) and Omani Beef: A Comparative Study

Isam T. Kadim, Osman Mahgoub and Waleed Al-Marzooqi

Comparative fatty acid composition of milk in Bactrian camel, dromedary, mare, cow and goat

B. Faye, G. Konuspayeva, M. Narmuratova, G. Loiseau

Lactoferrin and Immunoglobulin content in camel milk from Bactrian, Dromedary and hybrids in Kazakhstan

G. Konuspayeva, G. Loiseau, D. Levieux, B. Faye

DISEASES AND PATHOLOGY

Epidemiologic study of camel (*Camelus Dromedarius*) respiratory diseases in Nouakchott (Mauritania)

Kane Yaghoubia, Bada-Alamedji Rianatou, Kadja Mireille, Bezeid Ould El Mamy, Lena Philippe, Akakpo Justin and Kaboret Yalace

The Influence of Some Nematode Parasitism on Lipid Metabolism and Lipoprotein Profile In Dromedary Camel (*Camelus Dromedarius*)

Amr M. Mohamed, Mahmoud R. Abd Ellah, and Ghada A. Abou El-Ella

Laboratory testsof ruminants diseases in South American Camelids, an official directive before bringing animals to other countries or events: evaluation of the results from 1994-2006.

Ilona. Gunsser , Christian Kiesling

FOREWORD

This first issue of the Journal of Camelid Sciences is the result of an ambition: to give to the international scientific community working on small and large camelids the opportunity to publish regularly and easily some papers available on line. The aim is not to enter in competition with other existing reviews devoted to camelids and the objective is not to take the place of more specialized disciplinary reviews where camelid scientists are accustomed to publish papers. In 2006 for example, 219 papers devoted to large camelids were published in the world. There is a wide place for camel publications in specific journal.

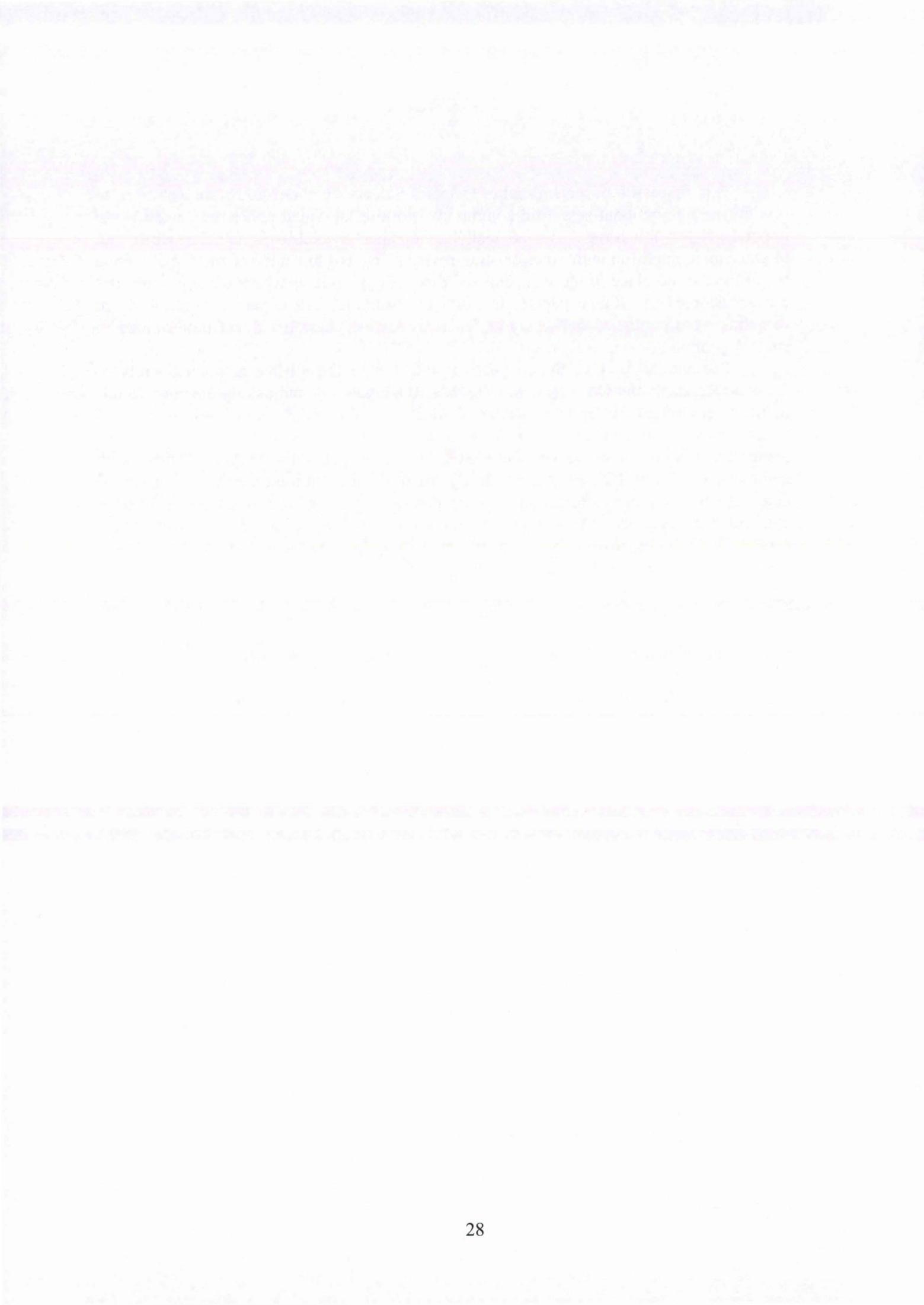
The Journal of Camelid Sciences is the tool of the « l'International Society of Camelid Research and Development » (ISOCARD, notably by publishing the proceedings of the international conferences that ISOCARD have for objective to organize every 3 years. Indeed, the content of this first issue includes some of the communications presented at the first conference where ISOCARD was created (at Al-Ain – United Arab Emirates, 15-17 April 2006). This on-line journal has for ambition also to sollicitate the camelid scientists for valorization of their results and for writing synthesis on various camelid sciences aspects. This ambition does not depend only to the editorial board of the review. It depends mainly of a collective voluntary to have a common tool for the dissemination of the knowledges in camelid sciences.

The chairman of ISOCARD

Dr Bernard Faye

The Editor-in-Chief

Pr Mohammed Bengoumi



ANNEXE 5

Sommaire du « CAMELPEDIA »

CAMELPEDIA

A camelpedia on ISOCARD website ?

The knowledge on camelid is widespread between around 250-300 scientists in the world and probably more vets and other actors of the camelid farming and camelid product processing. ISOCARD aims "to promote the camelid science and practice" according its status decided at the general Assembly hold at Al-Ain on April 2006. The present proposal is to share freely this knowledge through a "camelpedia" available on the website of ISOCARD (in English) and other website in local language if any.

The rule of Camelpedia will be similar to Wikipedia: every scientist having knowledge on one subject can propose a synthetic text. This text can be modified by other scientists having competence to do it. All subjects could be accepted if it concerns camel and camelid biology, history, farming, diseases and so on. The texts must be synthetic, not original results.

At first, I propose the following items, but more precise items could be added:

1. Origin and domestication
2. The camelids in the world
 - a. Small camelids of the new world
 - b. Camels of the old world
3. The camel in desertic ecosystem
4. The small camelids in Andin ecosystem
5. Breeds and types of camels and small camelids
 - a. General classification
 - b. Main breeds
 - c. Genetic markers
 - d. Hybrids
6. Anatomy
 - a. General anatomy
 - b. Internal anatomy
7. Physiology
 - a. Adaptation to underfeeding
 - i. Energetic under-nutrition
 - ii. Nitrogen under-nutrition
 - iii. Mineral under-nutrition
 - b. Adaptation to heat
 - c. Adaptation to drought
8. Reproduction
 - a. Sexual cycles
 - b. Copulation
 - c. Gestation
 - d. Parturition
 - e. Biotechnology of reproduction
9. Young camel rearing
 - a. Viability
 - b. Adoption techniques
 - c. Weaning techniques
 - d. Growth
10. Lactation
 - a. Milking by the young
 - b. Milking techniques

11. Nutrition

- a. Feeding resources
- b. Feeding behaviour
- c. Intake and digestibility
- d. Requirements

12. The productions

- a. Milk
- b. Meat
- c. Energy and work
- d. Wool
- e. Leather
- f. Other productions

13. The diseases

- a. Clinical examination and autopsy
- b. Pharmacology
- c. Infectious diseases
- d. Endoparasitosis
- e. Ectoparasitosis
- f. Metabolic diseases
- g. Systemic diseases

ANNEXE 6

Article soumis à BTER

EFFECT OF DIFFERENT SELENIUM LEVEL SUPPLEMENTATION ON SELENIUM STATUS IN CAMEL FROM UNITED ARAB EMIRATES

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Running Title: Selenium status in camel

ABSTRACT

Twelve female camels shared into 3 groups received after 2 weeks adaptation period, an oral Se supplementation (0, 2 and 4 mg respectively) for 3 months. Blood, faeces and urine samples were collected every 2 weeks up to one month after the end of the supplementation period. The Se concentration in serum was increased significantly in supplemented groups. The maximum level was observed in the period of supplementation in the camel receiving 4 mg (492.5 ng/mL) that was 4 fold compared to the value at the beginning of the trial (126 to 138.5 ng/mL according to the groups). The selenium concentration increased significantly in urine and faeces but in a less extent. A similar trend was observed with GSH-Px values varying between 22.0 and 427.7 IU/g Hb. But no difference occurred between the two supplementation period. Vitamin E (mean $1.13 \pm 0.61\mu\text{g}/\text{ml}$ with range 0.27-3.09) did not change significantly. Significant correlations were reported serum Se, GSH-Px, fecal and urinary excretion or concentration.

Index Entries : Selenium ; nutrition ; faecal excretion ; urine excretion; GSH-Px; camel

INTRODUCTION

The physiological peculiarities of camel face to mineral nutrition are an aspect of its adaptation to arid conditions and poor feeding resources (1, 2). Previous studies (3, 4) concerning trace elements as copper and zinc have shown a lower regulation level in plasma comparatively to other ruminants. Concerning selenium, there is little evidence to date of clinical deficiencies. Few results on plasma or blood values in field conditions in different areas from Morocco (5), China (6), Saudi Arabia (7) or in zoological parks (8) are available in the literature.

In United Arab Emirates (UAE), soils and feedstuffs are generally considered deficient in selenium, and many cases of degenerative myocarditis are observed (9). Thus, all concentrates given to camels are enriched in selenium under different forms. In a previous trial comparing cow and camel (10) where similar selenium supplementation supplied animals (with 2mg/day for 2 months), 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. However, the selenium metabolism is not studied in this species and it is 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 cow.

So, the present paper aims to study the kinetic of plasma selenium and other biochemical and mineral parameters at different level of selenium supplementation and to assess the selenium excretion in urine and faeces in order to understand the metabolism of this mineral.

MATERIAL AND METHODS

The objective of the study was to get references on plasma selenium and glutathione peroxidase by inducing a variation in the selenium supply and to analyze the possible interactions with other biochemical and mineral elements.

Animals

The study was achieved at Al-Foha farm belonging to the UAE University and included 12 non-pregnant and non-lactating female camels of local breed 6 to 13 years old, randomly shared into three groups of 4 animals. The approximate mean weights were 430 kg. The animals were treated for external and internal parasites using ivermectine (Ivomec N.D.) and were in good health during the whole experiment. They were weighed on electronic balance every week in the morning before feeding and watering. Internal temperature was reported every week at the weighing time.

Experimental procedure

During the whole trial, the animals were fed by using automatic individual gate to control the daily food intake. Camels received a basal diet including 6 kg D.M of *Rhodes* grass hay and 2kg of concentrates with known selenium content. The refusals were daily weighed and the quantity of grass adjusted to the mean intake. The animals were drunken *ad libitum*. The experiment (165 days) consisted of three phases:

1. *An adaptation period I (days 1-15)*. During this stage, the animals received the basal diet without any mineral supplementation to equilibrate their mineral status between groups. They did not receive any selenium supplementation.

2. *A supplementation period with selenium supplementation additives II (days 15-106)*. The group 1 (control group) did not receive oral selenium additive. The group 2 received 2mg of selenium under sodium selenite form (i.e. 4.36 mg of selenite). The group 3 received 4mg of selenium (i.e. 8.72 mg sodium selenite). The selenium supplementation was mixed with dates given daily as a delicacy to the animals.

3. *Post-supplementation period III (days 107-135)*. During this last period of the experiment, selenium supplementation was discontinued. Animals received the basal diet only.

Blood sampling

Blood was collected from the jugular vein into 5 tubes, three of 5ml heparinized vacutainer (H) and two of 10ml non heparinized vacutainer (NH). The tubes were centrifuged immediately. The plasma was harvested from H tubes. One was used for haematological analysis; one was used for mineral analysis and in the last one, red blood cells were rinsed three times with an isotonic solution of NaCl (0.9%) and centrifuged for 4 min at 4000 g. The supernatant was discarded and red blood cells were frozen at -70°C and kept until analysis of glutathion-peroxidase (GSH-Px). The serum was harvested from NH tubes. One was used for biochemical analysis and the second for mineral analysis including selenium (serum Se).

The blood sampling was carried out in the morning before feed distribution. During the first stage of the experiment, blood sampling was performed on days 1, 7 and 14. Thirteen samplings were carried out in the course of the second stage, once a week: day 22, 29, 36, 43, 50, 57, 64, 71, 78, 85, 92, 99 and 106. In the last stage, blood sampling was performed once a week also (day 113, 120, 127, 135).

Faecal and urine sampling

The faeces were sampled for 24 hours on each animal every two weeks all along the experiment. For this, animals were placed in individual box and all the faecal excretion on the cleaned ground harvested. The whole excretion was weighed. A sample of 600g was taken out, dried (at 65°C in stove for 48 hours), grinded then stored in plastic bag up to the analysis in a dry, dark and cool place.

Urine was collected for 24 hours with a plastic bag tied close to the vulva. The whole samples were weighed, acidified with HCl 0.1 M, and a part was poured in a 4-ml sterile flask then frozen at -20°C up to the analysis. Urine sampling was performed at the same interval than faeces sampling.

Feed and water sampling

The elements of the basal diet were sampled at the beginning and at the end of the trial, dried, grinded and stored for selenium analysis. Sampled water was also kept in the same time for selenium determination.

Laboratory analysis

Selenium was determined in serum, urine and faeces. Glutathion peroxidase activity was measured in erythrocytes. For selenium analysis, standards for whole blood and urine determination (Seronorm trace elements – Sero AS, Po box 24, NO-1375 Billingstad - Norway) were procured by Promochem Company (France). The analysis of selenium required the digestion of the samples to destroy proteins present and amino acids in order to release the molecules of Se related to proteins. The serum (2ml) was mixed in the tubes

of rotator's digester with 6ml hydrogen peroxide-30% then 1ml nitric acid-60%. The tubes were placed in the rotator then introduced into the apparatus. After digestion, the serum was analysed for the determination of serum selenium with Induced Coupled Plasma -ICP (Varian Vista MPX-CCD). Selenium in grass and concentrates was also determined with ICP.

Before analysis of GSH-Px, red blood cells were thawed to prepare a cellular suspension and lysate. A suspension was obtained by mixing 0.1 ml of red blood cells with 0.3 ml of an isotonic solution of NaCl. Samples were stored at -80°C up to analysis. Haemoglobin was measured in the suspension by colorimetry (Boehringer Mannheim kit, ref. 124729). Enzyme activity was measured in the lysate that was taken after mixing 0.1 ml of cellular suspension with 0.9 ml of distilled water. Glutathione peroxidase (EC. 1.11.1.9) activity was measured according to the method of Paglia and Valentine (11) (Randox kit, ref. RS 505). Haemoglobin concentration was measured by colorimetry (Boehringer Mannheim, ref. 124 729). Red blood cell enzyme activity was measured according to the specific reaction of each enzyme at 37 °C using the following Boehringer Mannheim kits. The GSH-Px activity was expressed in International Units per g of hemoglobin (IU/10g Hb) where 1 International Unit is equivalent to 1 mole of NADPH oxidized per min per g of hemoglobin.

Vitamin E concentrations were determined by high-pressure liquid chromatography (HPLC). For vitamin E determination, 1-ml samples of plasma were extracted using 1 times the sample volume of ethanol and 2 times the sample volume of hexane. Vitamin E was measured in the extracts as α -tocopherol by HPLC using a 3.9- x 150-mm silica column and UV detection at 292 nm. The mobile phase was hexane/chloroform (85/15) with isocratic elution.

In plasma, the others mineral parameters were trace elements (copper, zinc and iron). Following biochemical parameters were determined in the serum: glucose, creatinine, total proteins, albumin, bilirubin, CPK, Alkaline phosphatase, ALT, AST, LDH, GGT and vitamin E). The haematological parameters were estimated also including haematocrit, WBC, haemoglobin and blood formula (WBC/N, WBC/L, WBC/M, and WBC/E for neutrophile, lymphocyte, monocyte and eosinophile percentages)

Statistical analysis

Descriptive analysis (mean and standard deviation) were used to give raw results. Variance analysis was carried out using the XLstat software. For each variable to be explained (Se and GSH-Px), we tested the effect of the mineral supplementation period (3 levels: before, during and after), the treatment (0, 2 or 4 mg per day of Se supplementation) and the day of sampling (20 levels for blood and plasma, 10 for faeces and urine). Previously, normality of distribution was tested by the Skewness and Kurtosis test (test W). Interactions between other elements (minerals and biochemical parameters) were tested by Principal Components Analysis (PCA) and correlation coefficients determination. The relationships between quantitative variables were tested by the correlation of Pearson. The relationships between quantitative variables and rank data (groups 1, 2 and 3) were tested by the correlation of Spearman.

RESULTS

Selenium content in the diet and selenium intake

The selenium concentration was 0.49 mg/kg in concentrates, 0.15 in Rhodes grass. There was no Se in water. The feed intake was on average 6.37 ± 0.73 kg of grass and 2 kg of concentrate and did not vary significantly all along the experiment: it was respectively 6.27, 6.41 and 6.42 kg for the grass in group 1 (0 mg Se), 2 (2 mg) and 3 (4 mg) and respectively 6.29, 6.27 and 6.42 kg in the 3 successive periods. Thus, the selenium intake provided by the diet alone was 1.93 mg per day for camels during the period I and III. The mineral mixture providing 0, 2 and 4 mg of selenium per day, according to the treatment, the total quantity of selenium provided in the diet during period 2 was around 4 mg/day for camel in group 2 and 6 mg/day in group 3.

Mean values of selenium

On average, the mean value of selenium content in plasma was 275.1 ± 125.7 ng/mL ($n=240$) and varied between 91.6 and 596.6 ng/mL. The mean value was significantly higher at the periods II (during supplementation time) and III (after supplementation) compared to period I (table 1) at $P < 0.001$. When the Se supplementation was at 2mg daily, the plasma selenium concentration was on average two fold the concentration of control group. Similar trends all along the periods were observed in the three groups (figure 1). A significant difference in serum Se concentration occurred from week 4 ($P < 0.001$) between the treated groups and the control group. The maximum level was observed at week 11 in group 2 (414.1 ng/mL) and in group 3 (492.5 ng/mL) that was 3 and 4 fold respectively compared to the origin value (week 1: 126 to 138.5 ng/mL according to the groups).

In faeces and urine, 2 parameters were retained: the total Se excretion (SeExcF in faeces and SeExcU in urine) and the Se concentration (SeConF in faeces and SeConU in urine). On average, the camels excreted 1.70 ± 0.74 kg DM of faeces per day and 14.60 L of urine per day. The mean Se concentration was 581.0 ± 322.3 ng/g DM in faeces and 196.9 ± 130.0 ng/mL in urine with a total Se excretion of 980.7 ± 687.9 $\mu\text{g}/\text{day}$ in faeces and 1162.7 ± 1151.1 $\mu\text{g}/\text{day}$ in urine. There was no effect of Se supplementation both on faecal or urinary Se concentration or total excretion (table 2) in spite of a slight increasing in groups 2 and 3. However, the urinary Se concentration was significantly higher ($P < 0.05$) in group 3 at period III (318.9 ± 571.7 ng/mL), group 2 at period II (193.2 ± 212.7), group 2 at period III (220.7 ± 123.7) than group 1 at period 1 (46.0 ± 6.4). Elsewhere, on average, the observed faecal or urinary Se total excretion increased significantly at supplementation period and at the period 3 ($P < 0.001$). The faecal Se excretion was 2-fold in period 2 compared to adaptation period and urinary excretion 10-fold. The Se concentration was significantly much higher in urine at period 2 and 3 compared to first period (table 2).

Correlations between serum Se, urinary and faecal Se

Se concentration in serum was highly correlated with Se concentration in urine ($P < 0.001$) and in a lesser extent with the faecal concentration ($P < 0.05$) and total Se faecal excretion ($P < 0.01$) but not with total urinary excretion (table 3).

Mean values of GSH-Px

The red blood cell (RBC) GSH-Px activity varied between 22.0 and 427.7 IU/g Hb with a mean of 112.2 ± 6.26 IU/g Hb. The mean value was significantly higher at the periods 2 (during supplementation time) compared to period 1, but the GSH-Px activity was

decreasing significantly at period 3 (table 1) at $P < 0.001$. The values were higher in supplemented groups but on average there was no significant difference between groups 2 and 3.

The change all over the experiment (figure 2) confirmed that the GSH-Px activity was similar in groups 2 and 3. A significant difference occurred from week 6 ($P < 0.05$) between the treated groups and the control group, but the maximum level was observed at week 13 for group 2 with value (249.9 IU/g Hb) higher than the maximum value observed for group 3 in week 14 (208.0 IU/g Hb).

Mean values of vitamin E

The Vitamin E (α -tocopherol) in plasma was on average $1.13 \pm 0.61 \mu\text{g/ml}$ with a range of 0.27-3.09. There was no significant difference between the periods and the groups (table 1). However, the values from weeks 6 to 14 (except week 11), i.e at the supplementation period, were significantly lower than other weeks. The maximum mean value was observed at week 2 ($1.92 \mu\text{g/mL}$).

Correlations between serum Se, GSH-Px activity and vitamin E

All over the experiment, the serum plasma was correlated du GSH-Px activity ($r = 0.573$; $P < 0.001$) and GSH-Px activity was slightly negatively correlated to vitamin E ($r = -0.151$; $P < 0.05$). Within period, significant correlations Se plasma/GSH-Px activity was observed for period II ($r = 0.562$; $P < 0.001$) and III ($r = 0.484$; $P < 0.001$) only. No within-period correlation was observed with vitamin E.

Correlations with other blood parameters

Selenium concentration in serum was negatively correlated with other plasma minerals as copper (Cu) and zinc (Zn). Total protein and ALT was also negatively correlated to serum Se and GSH-Px activity. Only enzymes as AST and LDH were positively correlated to Se content in serum (table 4) but not GSH-Px. At reverse, vitamin E concentration appeared positively correlated to all enzymes (ALT, AST, LDH), as well as albumin and iron. Concerning haematology parameters, serum Se was negatively linked to WBC, but there were no relationships with the white cells formula, contrary to GSH-Px negatively correlated to neutrophiles and positively correlated with lymphocytes. Vitamin E concentration increased when PCV, neutrophile percentage and eosinophile percentage increased, but decreased when lymphocyte percentage was high.

DISCUSSION

In the United Arab Emirates, soil and consequently fodder are generally considered selenodeficient and the cases of degenerative myocarditis are regularly observed (9). So, the commercial concentrates used for camels were supplemented with selenium in various forms (sodium selenite, selenium combination and vitamin E), generally mixed in a mineral supplement or a pre mixture. The basal diet supplied camel with around 2 mg Se/day i.e. 0.25 mg/kg DM that was considered approximatively the requirements for dairy cattle (NRC, 2000) (12). However, according to the mean weight of the camels in our experiment (350 kg), the selenium supply with the basal diet was 0.55 mg/100kg LW that was lower than recommendations for beef cattle (1mg/100 kg LW).

Selenium metabolism in camel was not well known and few references were available. However, camel selenium deficiency was described in Canary Islands (13), in Saudi Arabia (7) or in Sudan (14). At our knowledge, no selenium intoxication case was reported.

Usual values of serum selenium

The mean concentration of serum selenium reported in the literature for large animals was 100ng/ml, value considered as sufficient for the maintenance of suitable metabolic functions (15). However, few references were available in camel serum.

In the dromedary from Morocco, Hamliri et al., (5) observed on whole blood, according to age and sex, values which varied between 109.1 and 117.8 ng/mL that were values similar to those reported on sheep in the same area (16). Similar figures were recorded by Liu et al., (6) in China with concentrations varying from 97 to 112 ng/mL. In Sudan, Abdel Rahim (17) reported values in whole blood varying between 25 and 53 ng/ml. Without specifying if it was whole blood or serum, Ma (18) reported higher values: 274 to 288 ng/mL.

Serum concentrations approached these last figures: 281ng/ml on average on sera coming from the Sultanate of Oman (Faye, unpublished data). In Morocco, in dromedaries receiving a low Se basal diet, the plasma selenium concentration was quite lower, about 21ng/ml (10), but the concentration increased up to 200.4 ng/ml after Se supplementation. In Saudi Arabia, serum Se values reported on young camels at slaughterhouse varied between 5.3 and 131 ng/ml with 30% of the samples above 100 ng/ml (19). In a previous study in Emirates (9), the mean value was 200 \pm 90 ng/ml on animals without Se supplementation. So, our current results seemed higher than the literature results. However, in small camelids as lama (20), the selenium concentration in serum was varying on average between 213 and 203 ng/ml according to the physiological status.

Usual values of RBC-GSH-Px activity

GSH-Px as one of the primary antioxidant enzymes is an important component in the protection against free radical damage to cells and thus is crucial to cell survival. Usually GSH-Px activity was considered as an indicator of selenium status in a variety of species (21). In a study achieved in Sudan, GSH-Px activity determined on whole blood was 6.32 EU/ml on male camel and 18.64 EU/ml on female camel (17). Those values were lower than 25.8 IU/g Hb reported by Hamliri et al. (5) and than 51.6 IU/g Hb reported by Bengoumi et al. (10) on non supplemented camels. In comparison, the values revealed by Corbera et al. (13) appeared very high (298.1 IU/g Hb in female camel). In 2mg-Se supplemented camels reported in Morocco, GSH-Px activity increased up to 131.7 IU/g Hb (10), values comparable to our results (124.7 IU/g Hb).

Usual values of plasma vitamin E

The vitamin E concentration in plasma in our results was quite similar to those described in the literature: for example 0.3 to 1.65 ng/ml in young camels from Sudan (19). Similar results were reported by Al-Senaidy (22) and Mousa et al. (23). Those values were lower than those reported in cattle (24).

Relationships between anti-oxidant parameters

A linear relationship between erythrocyte GSH-Px and whole blood Se concentration was already described in camel (5, 17). In our study, the relationship was highly significant but the correlation coefficient was lower than those reported by Corbera et al. (13), Abdel Rahhim (17) and Bengoumi et al. (10): respectively 0.88, 0.88 and 0.94. No data on correlation between Se and Vitamin E was available in camel, but similar lack of correlation was observed in other species (25, 26).

Changes in anti-oxidant parameters

In camel, the increase of selenium in serum and GSH-Px activity seemed very sensitive to the Se supplementation as it was reported in a previous study (10). In spite of the high level of serum Se concentration in control group, the values were 2-fold in treated group with 2 mg Se per day. The response was clearly higher than it was observed in cattle receiving the same quantity of Se supplementation (10, 27). With 4 mg supplementation, GSH-Px activity did not change significantly and the total selenium excreted by urine or feces did not change drastically in spite of the slight correlation between Se concentration in plasma and in feces. However, an important change in urinary Se concentration was observed. There was no data on urinary or fecal selenium excretion in camel, but in comparison with cattle the fecal and urinary concentration in our study was similar (27). In cattle, when the dietary intake was increased from 0.15 to 0.40 mg/kg DM, the selenium concentration in feces and urine increased significantly from 370 to 780 ng/g DM and from 20 to 180 ng/mL respectively (27). But, contrary to this former observation achieved on dairy cattle, no linear effect was observed in our study.

The lack of change in GSH-Px activity in the group receiving 4mg Se supplementation could suggest that we overstepped the requirements of camel in dietary selenium. After the end of supplementation period, camel was able to increase GSH-Px activity probably because of the high quantity of selenium stored in plasma. The selenium induces the biosynthesis of the glutathione peroxidase, seleno-dependent enzyme. When selenium supply was stopped, the plasma selenium level decreased but the GSH-Px activity was maintained in cattle either by the biosynthesis induction due to stored selenium or by the long plasmatic half-life of this enzyme. However, in camel, the plasmatic GSH-Px activity continued to increase, even if selenium supply was stopped and even if the plasma selenium concentration decreased. This increase could be explained by maintain of the biosynthesis induction in the camel erythrocytes from the selenium probably stored in the erythrocytes, and a longer plasmatic half-life of GSH-Px compare to cattle. In fact, the erythrocyte GSH-Px activity being closely related to the half-life to the red blood cells, the enzymatic activity is higher in camel than in cow when selenium was depleted because of the longer survival of camel erythrocytes (28).

There was a slight negative effect of Se supplementation on vitamin E concentration in plasma with a negative correlation between GSH-Px and Vitamin E. In pig, a lack of correlation was observed between Se concentration in serum and vitamin E concentration in plasma and no effect of dietary selenium was reported (25).

Relationships with other parameters

The negative correlation between Se and enzyme ALT could be interpreted like an opposition between these parameters as indicators of the cellular integrity. Indeed, selenium was an essential element of cellular protection and one could make the assumption that enzymes ALT and LDH, indicators of the cellular suffering, were all the more high as the concentration in Se was weak. On the other hand, CPK can show an intense activity at an early stage of the Selenium deficiency characterized by a muscular degeneration, but it was not the case in this study. At reverse, the positive relationship with AST and LDH was not in accordance with previous results (9). Moreover, all these enzymes were positively linked to vitamin E concentration. However all data concerning those enzymes were in the range of normal values in camel (29).

The negative relation between Se and other trace elements, as Cu and Zn, was unclear and not in accordance with previous results (9). There was probably interaction between selenium (Se^-) and copper or zinc (Cu^{++} or Zn^{++}). For example, in rat, zinc induced a decrease in the excretion of selenium in urine (30) and interaction at molecular level was described in human (31). But in other cases, no interaction was observed (32).

The results seemed to confirm the sensitivity of camel to Se supplementation with an important increase of selenium in serum. But this increase was not necessarily an example for the thrifty physiology, characteristic of the camel behavior. It could be also the mark of a greater sensitivity to toxicity, but the tolerance level to selenium toxicity in camel was not known.

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Table 1. Mean and standard-deviation of plasma concentration in selenium, glutathione-peroxidase and vitamin E according to the factors period (1 = before Se supplementation, 2 = during supplementation and 3 = after supplementation) and treatment (level of selenium supplementation, 0, 2 or 4 mg/day)

Parameter	Period			Treatment		
	1 (n = 36)	2 (n = 144)	3 (n = 60)	0 mg (n = 80)	2 mg (n = 80)	4 mg (n = 80)
Serum Se ng/µL	137.6 ± 18.7 ^a	301.0 ± 125.1 ^b	295.5 ± 108.6 ^b	153.6 ± 37.4 ^a	301.1 ± 84.1 ^b	370.8 ± 118.8 ^c
GSH-Px (ng/gHb)	82.9 ± 66.2 ^a	124.7 ± 63.3 ^b	99.7 ± 48.2 ^a	67.0 ± 23.8 ^a	145.0 ± 70.0 ^b	124.6 ± 54.5 ^b
Vitamin E (µg/ml)	1.61 ± 0.67	0.99 ± 0.50	1.16 ± 0.65	1.079 ± 0.57	1.09 ± 0.62	1.21 ± 0.63

^{a,b,c} Means with different superscripts differ ($P < 0.01$)

Table 2. Mean and standard-deviation of total Se excretion in faeces (SeExcF) and urine (SeExcU) and of Se concentration in faeces (SeConF) and urine (SeConU) according to the factors period (1 = before Se supplementation, 2 = during supplementation and 3 = after supplementation) and treatment (level of selenium supplementation, 0, 2 or 4 mg/day)

Parameter	Period			Treatment		
	1 (n = 12)	2 (n = 84)	3 (n = 24)	0 mg (n = 40)	2 mg (n = 40)	4 mg (n = 40)
SeExcF (µg)	518.8 ± 352.9 ^a	1060.5 ± 743 ^b	932.4 ± 486.7 ^b	888.9 ± 585.1	1079.1 ± 679	974.1 ± 773.2
SeExcU (µg)	136.3 ± 94.9 ^a	1257 ± 1167 ^b	1344 ± 1120 ^b	1063.1 ± 1014	1195 ± 1091	1229.4 ± 1318
SeConF (ng/g)	457.7 ± 208.0	621.8 ± 341.7	499.7 ± 263.0	562.0 ± 327.3	603.0 ± 280.4	578.0 ± 353.4
SeConU (ng/mL)	44.2 ± 7.2 ^a	200.5 ± 112.9 ^b	260.5 ± 155.3 ^c	173.8 ± 138.8	207.3 ± 125.1	209.3 ± 145.9

^{a,b,c} Means with different superscripts differ ($P < 0.01$)

Table 3. Correlation coefficient between total Se excretion in faeces (SeExcF), urine (SeExcU), Se concentration in faeces (SeConF), urine (SeConU) and serum Se * $P <$

Variables	SeConF	SeConU	SeExcF	SeExcU	Se serum
SeConF	1				
SeConU	0,608**	1			
SeExcF	0,839**	0,569**	1		
SeExcU	0,466**	0,659**	0,470**	1	
Se serum	0,192*	0,300**	0,265**	0,154	1

concentration 0.05; ** $P < 0.01$.

Table 4. Correlation coefficients between Se serum concentration, GSH-Px and vitamin E in one hand, and blood parameters in a second hand.

Variables	Se serum	GSH-Px	Vitamin E
PCV	0,055	-0,046	0,250
HB	0,043	0,042	-0,019
WBC	-0,149	-0,220	-0,095
WBC / N	0,057	-0,146	0,164
WBC / L	-0,066	0,183	-0,235
WBC / M.	-0,120	-0,070	0,042
WBC/ E.	0,043	-0,095	0,164
Cu	-0,276	-0,240	0,031
Zn	-0,131	0,023	-0,036
Bilirubin	-0,011	-0,008	0,071
Glucose	-0,087	-0,057	0,122
Creatinine	-0,106	-0,030	0,008
Total protein	-0,339	-0,231	-0,125
Albumin	0,022	0,037	0,158
ALP	0,017	0,039	-0,097
CK	-0,072	0,037	0,083
ALT	-0,247	-0,188	0,240
AST	0,189	0,105	0,249
LDH	0,168	0,067	0,206
GGT	0,018	-0,114	-0,031
Fe	0,102	-0,007	0,247

Figure 1. Change in serum Se concentration according to the Se supplementation level in camel

Figure 2. Change in RBC SSH-Px activity according to the Se supplementation level in camel

Figure 3. Change in plasma Vitamin E concentration according to the Se supplementation level in camel.

