

The background of the cover is a close-up photograph of several tomatoes. One tomato in the foreground is green and unripe, while others in the background are red and ripe. The lighting is soft, highlighting the texture of the tomato skins.

# Journal of Medicinal Plant Research

Volume 8 Number 23, 17 June, 2014

ISSN 2009-9723



*Academic  
Journals*

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Full Length Research Paper

## Ethnobotanical use of *Commiphora swynertonii* Burrt. amongst Dorobo people in Tanzania

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Received 3 May, 2014; Accepted 20 June, 2014

Dorobo, a sub-ethnic group of Maasai tribe in Tanzania, live in very remote areas without health facilities and hence depends entirely on plant and animal products for food and medicines. This paper describes attitude, beliefs and use of traditional medicines amongst Dorobo people, with a particular prominence to *Commiphora swynertonii* plant because of the reported extensive use by the Dorobo for treatment of a multitude of diseases both in humans and livestock. Information was collected *via* focus group discussion (FGD) held in Erkesumet Township and Kitwai village in Simanjiro District, Manyara Region, Tanzania, between July and August, 2013. It was found out that Dorobos without regard to status or wealth use ethno-botanic medicines as first-line except for serious or recalcitrant diseases. They believe that herbal medicines are readily available, effective and affordable and have no side effects compared to modern medicines. *C. swynertonii*, the most popularly used plant is used to cleanse the body and protect or treat various diseases such as sexually transmitted infections, skin infections, worm infestation, coughs and other chest problems in both humans and livestock. The bark exudate is used to kill or repel ticks and other insects on livestock and poultry. Dorobos are worried about the future sustainability of ethnobotanical knowledge and availability of medicinal plants because of human developmental activities that are advancing in their living environs.

**Key words:** *Commiphora swynertonii*, Oltemwai, natural acaricide, Dorobo, ethnobotanical knowledge.

### INTRODUCTION

Dorobo is a Maasai sub-ethnic group living in the Northern part of Tanzania and Southern part of Kenya (Figure 1), with a population of less than 1,000 people

(Legère, 2002). Maasai people are rich with appreciable number of cows, goats and sheep (Ole Sankani, 1995). Dorobo are Maasai of low cadre because they are poor.

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Figure 1. The Maasai land of East Africa.

In Maasai language the name Dorobo (pronounced *il tórobò*) literally means “the ones without cattle” which actually means “poor people”. Most of them live in isolation in remote areas, away from civilization and depend on wild fruits, roots, milk, honey and game meat for food (Kenny, 1981). Infrastructure is non-existent; there are no roads, hospitals nor schools. Living in remote hard-to-reach places which hardly receive modern health services from state-run organs or non-governmental organizations, Dorobos, depend very much on their ethno botanical knowledge to treat or manage ailments and diseases (Ole and Beckwith, 1990; Ole, 2005; Bussmann et al., 2006).

Being a sub ethnic group of Maasai, this is not surprising because Maasai are famous in East Africa for their traditional herbal medicines, which have been scientifically proven to treat a wide range of diseases – from high blood pressure and diabetes to viral, bacterial, fungal and parasitic infections, including malaria and tuberculosis (TB) (Kiringe, 2006). The use of plants by Maasai tribe (including Dorobo) for medicinal purposes has been deeply investigated by Bussmann et al. (2006). Some popular plants for medicinal purposes include *Commiphora* species, *Sericocomopsis hildebrandtii* Schinz., *Achyranthes aspera* L., *Warburgia salutaris* (Bertol.f.) Chiov., *Acacia nilotica* (L.) Willd. ex Delile, *Albizia anthelmintica* Brongn., *Euphorbia meridionalis* Bally & S. Carter and *Rhamnus prinoides* L'Hér (Bussmann, 2006; Bussmann et al., 2006). One of the most popular plants used for medicines by Dorobos is a plant known locally as *Oltemwai*. The plant is used by all Dorobos and many other tribes in Tanzania for treating many ailments (Sindiga, 1992). The plant has been identified as *C. swynertonii* Burt. (Sambuta and Masola,

2006) and is depicted in Figure 2a and b.

*C. swynertonii* belongs to the genus *Commiphora* (fam. Burceraceae). The genus has been researched extensively with regard to its applications in ethnomedicine. Shen et al. (2012) reviewed traditional uses, phytochemistry and pharmacology. Resinous exudates of the bark of the genus *Commiphora* have been proved to have anti-inflammatory, antimicrobial and anticancer activities. They have been used for treatment of arthritis, hyperlipidemia, cardiovascular and gynecological diseases. The Chemistry of the genus *Commiphora* has also been extensively studied and more than 300 compounds have been isolated and identified (El Ashry et al., 2003; Hanuš et al., 2005; Ahmed et al., 2006; Shen et al., 2007; Su et al., 2012), including flavonoids, terpenoids, steroids and phytostrerols. Other constituents include carbohydrates, lignans and long aliphatic chain derivatives. The Dorobos refer to *C. swynertonii* exudates as a “wonder drug” as it is used to treat many ailments and also used as prophylaxis against ill-health. Leaves, roots, barks and exudate tapped from incisioned barks of the tree (Figure 1) are used for various medicinal applications both in humans and animals. The exudate is also used as an acaricide against ectoparasites in cattle, sheep, goats and poultry.

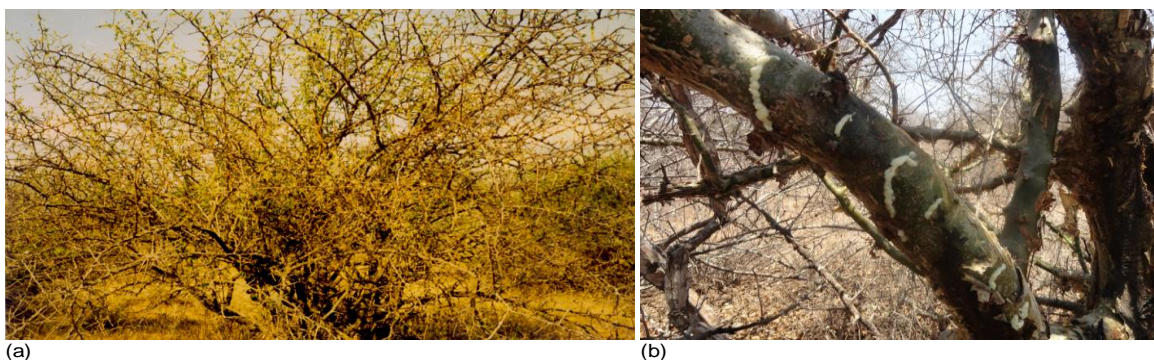
The aim of this study was to investigate the attitude, beliefs and use of ethno botanical products by Dorobo people for medicinal purposes in both humans and animals. A special attention was accorded to *C. swynertonii* due to its popularity in use amongst Dorobos. The findings in this study were expected to appraise interest to scientists to further investigate and tap the potentials therein that may supplement the current medicines in health care. Exploitation of this potential may also improve economic status of the Dorobos through commercial use of local medicinal plants.

## MATERIALS AND METHODS

Information on the uses of *C. swynertonii* by Dorobo tribesmen was collected via focus group discussions (FGD) held in Erkesumet township and Kitwai village in Simanjiro District (4° 00' 00" S and 36° 30' 00" E; 1,455 m above sea level), Manyara Region, Tanzania, between November and December, 2013. A tape recorder and a video camera were used to record the discussion, in addition to writing notes manually.

FGD method was purposefully chosen based on suitability and convenience. Conventional interview using structured or semi-structured questionnaires would have expressed more representativeness, but in the circumstances it was not practical because of the difficulty to reach prospective respondents and the time required thereof. Dorobos live very far apart. Each Boma (the household unit) is at least 10 km apart and the only way to travel is on foot. Moreover, most Dorobos do not speak Kiswahili (the National language), and many cannot write or read. Dorobos are also reluctant to talk with strangers. Conventional interview would involve distributing questionnaire and collecting them which would





**Figure 2.** (a) *C. swynertonii* tree in Simanjiro, Northern Tanzania, (b) Exudate oozing from *C. swynertonii* after incising the bark with a knife.

be very tedious, time consuming and expensive. FGD on the other hand involved actively selecting participants and convening them at one station. Participants of the FGD were identified and recruited by a local leader in accordance with the specifications from the authors. Inclusion criteria to participate in the discussion were being Dorobo tribe, willingness to participate, ability to speak Kiswahili (Tanzania national language), possession of at least 5 cows or 10 sheep and goats for men and their willing wives, or local leaders. The total number of Dorobos in Tanzania does not exceed 1,000 people (Legère, 2002).

According to local authorities, Dorobo inhabitants where this study was done are estimated at around 150 to 180 people (verbal communication with the local leader, Mr Alamunyaki Kloriti). The Erkesumet group comprised 8 men and 3 women, while that of Kitwai village had 9 men and 2 women. Erkesumet being a township has small shops that sell modern medicines while in Kitwai the place is quite remote and health facilities are far away. The objectives of the FGD were to investigate the attitude, beliefs, knowledge and use of medicines of ethnobotanic origin. The discussion focused on the use of traditional remedies in various disease, local names of popularly used medicines and the diseases they treat, how the medicines are prepared and used, how traditional medicines compare with modern medicines, challenges facing the application of traditional medicines and future of ethnobotanical knowledge of Dorobos. A special treat was directed towards the use of *C. swynertonii* because of its popularity in use amongst Dorobos.

Contribution of ideas by the participants was free and random, that is there was no particular order of responding. The moderator introduced a theme and directed the discussion. Each participant was asked to give his/her response, which was recorded. Based on the responses, the moderator probed more into the theme. Information obtained was transcribed and the emerging themes were grouped together, coded and analyzed. Microsoft Excel 2007 program was used to calculate frequencies of responses. Three quantitative indices were used to calculate agreements of participants for the purpose of drawing conclusion, and these are:

1. Relative frequency of citation (RFC) which shows the local importance of each medicinal plant (Vitalini et al., 2013). It is calculated as follows:

$$RFC = \frac{FC}{N}$$

Where FC = number of participants mentioning the use of the plant

and N = total number of participants

2. Fidelity level (FL) which is used to indicate the percentage of participants claiming the use of a certain plant for the same medicinal purpose (Jacobo-Salcedo et al., 2011), and is calculated as follows:

$$FL (\%) = \frac{N_p}{N} \times 100$$

Where  $N_p$  is the number of participants who claim use of a given plant and N is the total number of participants.

2. The index of agreement on remedies (IAR), which gives a consensus index of participants about the use of a remedy for a given health condition (Mutheeswaran et al., 2011), which was calculated as follows:

$$IAR = \frac{nr - na}{nr - 1}$$

Where  $nr$  is the total number of citations registered for a plant,  $na$  is the number of illness categories that are treated with the plant.

## RESULTS

A total of 29 Dorobo tribe participants (males = 75.9%, Females = 24.1 %) participated in two FDGs conducted in Erkesumet and Kitwai village in Simanjiro district, Northern Tanzania. Majority of participants (86.2%) had no formal education, 13.8% had primary school education and no participant had gone beyond primary education level. On average, each family had 6 cows, 8 goats, 4 heep, 1 donkey and 4 chicken. From the FDGs, it was found that all Dorobos used local medicinal plants as First-line help. All participants have used medicinal plants at least once in their lives. Most participants preferred herbal medicines to modern medicines except some younger participants who live near Erkesumet township (13.9%) who preferred modern medicines to treat non-

responding disease such as Malaria, East Coast Fever (ECF) and trypanosomiasis. The young participants who preferred modern medicines also argued that compared to modern medicines, use of local medicines are cumbersome because fresh supplies are required all the time unlike modern medicines. Moreover there are no clear doses in local medicines. Furthermore, herbal medicines were used by all people regardless of social status or wealth. Traditional medicines were preferred because they were affordable and easily accessed, and effective in treatment of various common diseases including wounds, eye infections, skin conditions, animal problems such as retained placenta and hoof and horn lesions. Herbal products were also said to be effective ecto-parasiticides and endo-parasiticides. Dorobos did not have specialized traditional healers because the traditional medicines were universally known to all Dorobos. Any member of a family could collect and prepare any medicine. Local names of 25 most popularly used medicinal plants are listed in Table 1 along with their RFC, FL and IAR.

Regarding threats on the future of ethnobotany amongst Dorobo people, participants expressed concern about the gradual disappearance of medicinal plants due to human deforestation for agricultural development and habitation. Natural forest close to townships was said to be depleted for firewood, charcoal-making, furniture and building materials. Participants of the FGD reported that traders from outside the area (elsewhere in Tanzania and outside Tanzania) were flocking in the area in search of *C. swynertonii* exudates and other medicinal plants. Furthermore they pointed out that harvesting of medicinal plants was not controlled in any way and no new plants were sowed. Dorobos also expressed worry with regard to sustainability of ethnobotanical knowledge. Traditionally adults pass ethnobotanical information to the young ones to sustain traditional norms and knowledge. However due to changes in the ways of life, the young generation is tending to move to urban areas in search of employment thus eluding cultural information inheritance which include knowledge of important botanical remedies.

The results of the FGD are tabulated in Table 2. Medicinal uses of various plant parts (leaves, barks, bark exudate and roots) of *C. swynertonii* are listed in Table 3.

## DISCUSSION

Participants of the FDGs explicitly supported that Dorobos depend very much on ethno botanical medicines to treat various ailments both in human beings and their livestock. Dorobos live in remote areas, without communication to the outside World. There are no health facilities where they live. With plenty of flora surrounding

them, and their ethnobotanical knowledge, Dorobos exploit the situation to feed themselves and treat ill health using various plants. Having had no experience with modern medicines, Dorobos believe more in their local medicines than foreign medicines. To them, herbal medicines are effective (and more effective than modern medicines), have no side effects, and are readily and freely available. However, some younger generation who live near Erkesumet Township, who had been treated with modern medicines prefer modern medicines. The latter claim that herbal medicines are cumbersome to use, have no clear doses and that some are not as effective. Dorobos also assert that there are some few diseases in which herbal medicines are not effective. These include trypanosomiasis and East Coast Fever. In such diseases, Dorobos seek modern remedies.

Participants mentioned several plants being used by Dorobos for medicinal purposes as represented in Table 1 along with their RFC, FL and IARs. The value of RFC ranges between 0 and 1. The value 0 means that nobody referred to the plant as useful while the value 1 means that all participants referred to the plant as useful. In this study, Oltemwai, omisera and Oiti had RFC value 1 meaning that all participants referred to the plants as effective ectoparasiticide, milk stimulant and antidiarrhea, respectively. Oltemwai (*C. swynertonii*) had the most listed illnesses more than all the plants and all participants concurred that they all use it and also kept it in their homesteads as First-Aid remedy. Thus more attention was accorded to the plant to probe for more information. Participants mentioned several uses of Oltemwai including treatment of sexually transmitted disease, ulcers and wounds (cut wound or burn wounds), recalcitrant ulcers abscess swelling of legs (leg edema), chesty cough (which some participants called tuberculosis) and scabies. The exudate is also used to cleanse bladder and kill insects such as ticks, lice, bed bugs and mange mites. Participants also claimed that the exudates is a worm expeller and treats dental carries. Oltemwai also had fidelity level (FL) value 100% as ectoparasiticide and for the treatment of wounds and recalcitrant ulcers. FL is the percentage of participants claiming the use of a plant for the same medicinal use. The value of FL ranges between 0 and 100%. The value 100% for Oltemwai means that all participants unanimously asserted the uses of oltemwai in these activities.

In order to assess the agreement among participants regarding the acceptability of mentioned medicinal plants, the value of IAR were determined as indicated in the methodology. IAR ranges between 0 and 1. The value 0 means that the number of illnesses equals the number of citations by participants while the value 1 means that all participants agree upon the exclusive use of the species for the particular illness. Omisera for instance has a value

**Table 1.** Dorobo local names of commonly used medicinal plants.

Dorobo names of medicinal plants	RFC	Disease treated by the plant	FL (%)	IAR
Oitemwai	1	Ectoparasiticide (kills ticks, fleas, mange mites, bed bugs)	100	0.6
		Dental pain	86	
		Worms Expeller	90	
		Sexually transmitted Infections (STI)	93	
		Chest problems, and coughs	86	
		Wounds / recalcitrant ulcers	100	
Eluai	0.69	Retained placenta	93	0.97
Omisera	0.75	Retained Placenta	50	0.62
Okiperema	0.86	Retained Placenta	76	0.83
Engaiteteyai	0.9	Ulcers, wound	93	0.86
Engaiteteyai	0.83	Respiratory infections	83	0.86
Orkumbai	0.83	recalcitrant ulcers	0.93	
Oremit,	0.93	Malaria	75	0.66
	0.7	Early stages of East Coast Fever	0.59	0.55
	0.76	Biliary disease	0.66	0.72
Osokonoi	0.9	Mild trypanosomiasis	72	0.8
Engokii,	0.62	Bloody urine	59	0.72
Olchokii	0.66	Bloody urine	55	0.62
Oirii	0.72	Bloody urine	66	0.72
Amg'arooji	0.86	Bloody urine	59	0.66
Omisera	1	Milk stimulant	100	1
Oiti	1	Diarrhea	93	0.86
	0.8	Stomach ache	93	0.79
Osilalei	0.86	Diarrhea	72	0.76
Entemelua	0.7	Malaria	83	0.9
	0.59	Typhoid	55	0.7
	0.66	Arthritis	86	0.7
Omgosua	0.72	Induction of emesis	83	0.72
Esiteti	0.7	Malaria	76	0.7
	0.55	Arthritis	59	0.66
Alisikirai	0.79	Malaria	76	0.7
Oikiperema	0.72	Malaria	72	0.72
Oldupai	0.9	STI	83	0.72
Oloisuki	0.72	STI	66	0.59
Oloirien	0.7	Malaria	80	0.7
	0.55	Pneumonia		

\*RFC = Relative frequency of citation, FL = fidelity level and IAR = index of agreement on remedies.

**Table 2.** Results of focus group discussion on beliefs and use of traditional medicines.

Points of discussion	Summarized responses
Preference of first-line health remedy between traditional herbal remedies and modern medicines remedies	Dorobos prefer Herbal medicines to modern medicines as first-line treatment
Reasons for preference in (1) above	Herbal medicines are affordable (they are free), readily available, and no side effects; Herbal medicines are stronger and more effective than modern medicines
Diseases believed to be effectively cured by traditional herbal medicines	<b>Human ailments:</b> Malaria, Snake bites, Worm infestation, General malaise, Eye infections, Liver and kidney diseases, wounds, coughs, Palpitations, Diarrhea., Reduced male virility (use of aphrodisiacs), sexually transmitted diseases, indigestion, pain (backache, joint pain, headache), chest infection (pneumonia or Tuberculosis). <b>livestock ailments:</b> eradicate ecto and endo parasites (ticks, fleas and mange mites),, hoof and horn lesions and management of retained placenta, Worms, wounds, ulcers, diarrhea, skin conditions, babesiosis, coughs and respiratory infections, myiasis, calf scours., Foot and mouth disease
Health problems not amenable to herbal medicines (that require Modern medicines)	Ndorobo (trypanosomiasis) and Ndigana (East Coast Fever) in livestock. Dorobo claim to treat all human ailments including cancer
Possibility of replacing herbal medicines with Modern medicines	According to Dorobo Beliefs, it is impossible to replace traditional medicines because Herbal medicines are effective, available, and cheap. Modern medicines are not as effective, may have “bad effects” and very expensive. However some diseases do not respond to traditional herbal medicines and therefore need modern medicines
Uses of <i>C. swynnertonii</i> (see table 2 for preparation of the medicines and applications)	Sexually transmitted disease , ulcers and wounds (cut wound or burn wounds), recalcitrant ulcers abscess swelling of legs (leg edema), chesty cough (Tuberculosis?), scabies, body cleansing, bladder cleaning, Acaricide, Worm infestation, skin diseases ( fungal infection?), Dental carries.
Challenges facing ethnobotanical supply and knowledge amongst Dorobo	Some of Dorobo children are leaving to go to towns to look for employment. They will not know traditional medicines and knowledge will disappear Herbal medicines cannot be kept for a long time. Usually fresh supply is needed each time. This is wasteful Some areas where we used to get medicines are now restricted or some have been developed for agricultural activities Harvesting medicinal plants is not controlled. Some plants may disappear. Some medicines are becoming popular to outsiders. <i>C.swynnertonii</i> exudate is overharvested for sale. 1 liter can fetch as much as 10,000 shillings
Willingness of participants to support research in tradition medicines	All suggested Research to be conducted. Majority (81%) agreed to participate should they be asked to volunteer in research, while 19 % refused with reasons that “outsiders” want to steal their knowledge

1 meaning that all participants agreed that is an effective and solely used for stimulation of milk from cows. The IAR for oltemwai is 0.6, meaning that 60% of participants asserted that oltemwai is effective in 3 out of 6 mentioned medicinal activities. All participants knew oltemwai and have used it at least once in their lives. With a highest RFC and FL, Oltemwai was the most popular medicinal

plant amongst participants of the FDG.

The native uses of Oltemwai (*C. swynnertonii*) are supported scientifically by research results. Bakari et al. (2012a) confirmed the antibacterial and anticandida activities of the plant thus supporting its use as anti-infective in chest problems, fungal infections, wound treatment, diarrhoea and sexually transmitted diseases.

**Table 3.** Medicinal uses of *C. swynertonii* as narrated by Dorobos in FGD.

Part of the plant	Medicinal Uses	Dose and mode of administration
Exudate tapped by incision of the bark	Sexually transmitted diseases	One teaspoonful taken as single dose. A second dose may be necessary
	Recaltrant cough	One teaspoonful daily for three days
	Diarrhoea	A teaspoonful of exudates diluted in a cup of water and taken whole
	Wounds, abscess and skin infections	Apply the exudates directly on the affected area. Treat until when the symptoms disappear
	Worms (all kinds)	Dilute a teaspoonful of the exudates in a glass or cup of water. Single dose recommended but can add a second dose
	Insect repellent	Dilute one cup of the exudates into one pail (about 20 litres) of water. This liquid is enough for 50 cows
Leaves	Acaricide in livestock	Dilute about one liter of the exudates in one pail (about 20 litres) of water and spray or bathe the animal. The diluted exudate is sometimes boiled to enforce dissolution
	Insect repellent	Leaves are crushed and mixed with water. The resulting mixture is applied on animal hides to repel insects
Roots	Swelling of legs (interpreted by the authors as Peripheral edema from the reported symptoms)	The roots are cut in small pieces and boiled in water and patients are given a glass or cup of the concoction once daily for a week or up to ten days or when the edema subsides.
Barks	General Health Maintenance	Boil and drink regularly

Bakari et al. (2012b) confirmed the antiviral activity of volatile oils from the exudates of *C. swynertonii* and suggested the use of the exudates for treatment of Newcastle disease in poultry. Kaoneka et al. (2007) also demonstrated the repellency activity of essential oils the leaves of *C. swynertonii*. The authors are currently bio-assaying other claimed activities such as wound healing, antihelminthic, antimicrobial and anti-inflammatory activities.

Although the Dorobo have great belief in the effectiveness of herbal medicines, particularly *C. swynertonii*, and some of their claims have been proved albeit *in vitro* there are no deliberate efforts to tap this potential commercially. This study therefore will pave way to attempt bio-assaying the claimed activities to lay grounds for further research on the potentials of the plant.

This study also unveils the unchecked harvesting of the *C. swynertonii* plant. Participants of the FDG expressed fear that the rate at which it is used puts it in danger of extinction. During the FDG, it was learnt that there is no control on the harvesting of the exudates of the plant. It may be argued that harvesting the exudates causes minimal damage to the plant, but if the process is not controlled it may lead to damage and death of the plant. This is exemplified by haphazard harvesting of *Commiphora guggul* in India and Pakistan. The plant *C. guggul* was indiscriminately harvested for its extensive

traditional medicine applications. It reached a point of extinction and was once listed on the International Union for Conservation of Nature (IUCN) red list of threatened species (<http://www.iucnredlist.org>). The plant became endangered because of excessive unscientific tapping for its gum resin by the pharmaceutical industries and religious prophets (Soni, 2008). *C. guggul* just like *C. swynertonii* has slow growing nature, poor seed setting and poor seed germination rate. To address this situation India's National Medicinal Plants Board launched a project to educate her people on good propagation and conservation of *C. guggul* (Maheshwari, 2008). Today *C. guggul* is commercially grown in China, India and Pakistani. Also an improved tapping technique using "Mitchie Golledge knife" coupled with ethephon application has been developed which enhances gum production by about 22 times over that obtained from control and rapid wound healing (Bhatt et al., 1989).

*C. swynertonii* may economically liberate the Dorobos and other tribes where this plant thrives. In China, India and Pakistan, *C. myrrh*, *C. wightii*, *C. muggul* and *C. molmol* are cultivated commercially due to their great financial output. Some communities in the horn of Africa (Eritrea, Ethiopia, Djibouti and Somalia) solely depend on these plants for their income. Indigenous people of these countries derive revenue from the sale of *Commiphora* products (Coulter, 1987). Promoting commercial exploitation

of *C. swynertonii* could serve as one way of poverty alleviation to the beneficiaries, the Dorobo and other people where *C. swynertonii* thrives. Alternatively, the active ingredients can be produced through cell culture system or biosynthetic pathways which obviate extraction from plants. The efforts may further be supplemented by studies to improve methods of seed germination. Jain and Bashir (2010) suggest use of *in vitro* somatic embryogenesis, to replenish endangered plants through cell culture. The authors further suggest studies to be conducted to help cultivation of superior genotypes, take up trans-genetic studies to conduct breeding experiments for propagation of improved germplasm. More important methods of *in situ* conservation should be applied to conserve existing trees in their natural habitat.

## Conclusion

Dorobo people use ethno botanical medicines as first-line to treat and prevent diseases both in humans and their livestock. Several species are used to manage a broad spectrum of diseases afflicting the Dorobo community. In few incidences however, some diseases such as trypanosomiasis and East Coast fever do not respond to local medicines and hence Dorobos can afford to use modern medicines to treat them. Ethnobotanical knowledge is passed through generations from adults to children. *C. swynertonii* is widely applied for various ailments by all Dorobos particularly for treating wounds, sexually transmitted diseases, respiratory infections in humans and acaricidal activity in livestock and poultry. The acaricidal activity and repellency has been bioassayed in ticks and proved in the laboratory. There are concerns on sustainability of ethnobotanical use and knowledge among Dorobo.

Haphazard and indiscriminate harvesting of medicinal plants, deforestation of areas where medicinal plants are found and migration of the younger generation to urban areas jeopardizes future of ethnomedicine knowledge and use.

Efforts from stakeholders (scientists, state organs and Non-governmental organizations) should deliberate to intervene. The community should be educated on economic importance of medicinal plants. Bioassay of claimed activities particularly wound treatment, anti infective activity and acaricidal activity is being conducted and where results are prospective, commercial exploitation shall be considered. This will be beneficial both medically and economically to local communities.

## ACKNOWLEDGEMENTS

The authors wish to thank SIDA-SAREC for funding the research. We also appreciate the assistance of Simanjoro

local government leader, Mr. Abdul Mwinyihamisi for his assistance in mobilizing participants of the FGD.

## Conflict of interests

The author(s) have not declared any conflict of interests.

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Full Length Research Paper

# Successive variation in phytosociological aspects and threat categorization of *Picrorhiza kurroa* Royle ex Benth. in Kumaun Himalaya of Uttarakhand

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Received 7 March, 2014; Accepted 19 June, 2014

The present work is a part of a three years extensive study to observe the annual changes in phytosociological characters of *Picrorhiza kurroa* Royle ex Benth. (Family- Scrophulariaceae) in high altitudinal regions of Kumaun Himalaya, Uttarakhand. The work was undertaken with the objective of observing the annual variation in relative values of frequency, density, abundance and importance value Index (IVI) of the plant species suffering from threats and categorized as critically endangered by International Union for Conservation of Nature (IUCN).

**Key words:** Phyto-sociology, Scrophulariaceae, population, Kumaun, assessment.

## INTRODUCTION

Phyto-sociology is the study of the characteristics, classification, relationships, and distribution of plant communities. It is useful to collect such data to describe the population dynamics of each species studied and how they are related to the other species in the same community. Subtle differences in species composition and structure may point to differing abiotic conditions such as soil moisture, light availability, temperature, exposure to prevailing wind, etc. When tracked over time, species and individual dynamics can reveal patterns of response to disturbance and how the community changes over time. The term phyto-sociology was coined by Jozef Paczoski in 1896.

The aim of phyto-sociology is to achieve a sufficient empirical model of vegetation using plant taxa

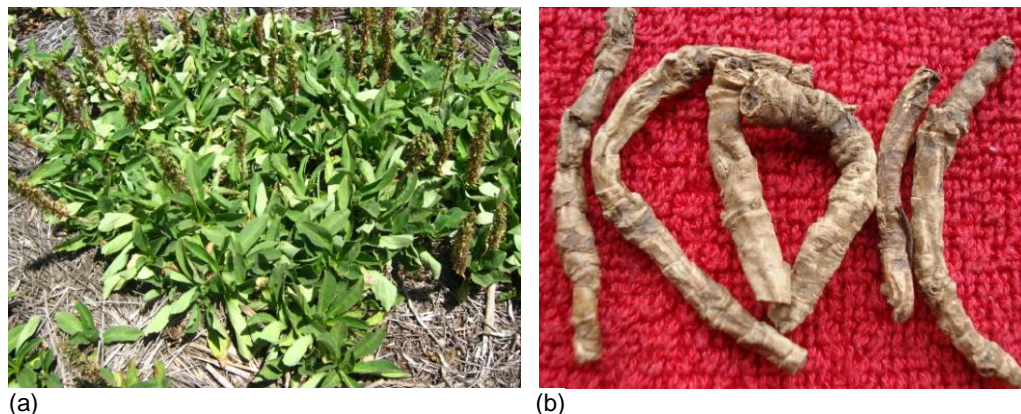
combinations that characterize univocally vegetation units. Vegetation units as understood by phytosociologists may express largely abstract vegetation concepts (for example, the set of all hard-leaved evergreen forests of Western Mediterranean area) or actual readily recognizable vegetation types (for example, cork-oak oceanic forests on Pleistocene dunes with dense canopy in SW-Iberian Peninsula). Such conceptual units are called "syntaxa" (singular "syntaxon") and can be set in a hierarchy system called "synsystem" or syntaxonomic system.

In this work, the phytosociological aspects of *Picrorhiza kurroa* Royle ex Benth. belonging to the family Scrophulariaceae (Plate 1) were observed and analyzed to sculpt the annual fluctuation in various aspects of

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**Plate 1.** *Picrorhiza kurroa* Royle ex Benth. in (a) natural habitat and (b) roots.



**Figure 1.** Study area map- Kumaon Region.

phyto-sociology. The observations were made on the year wise variation in relative frequency (Rfr), relative density (RDen), relative dominance (RDom) and importance value index (IVI).

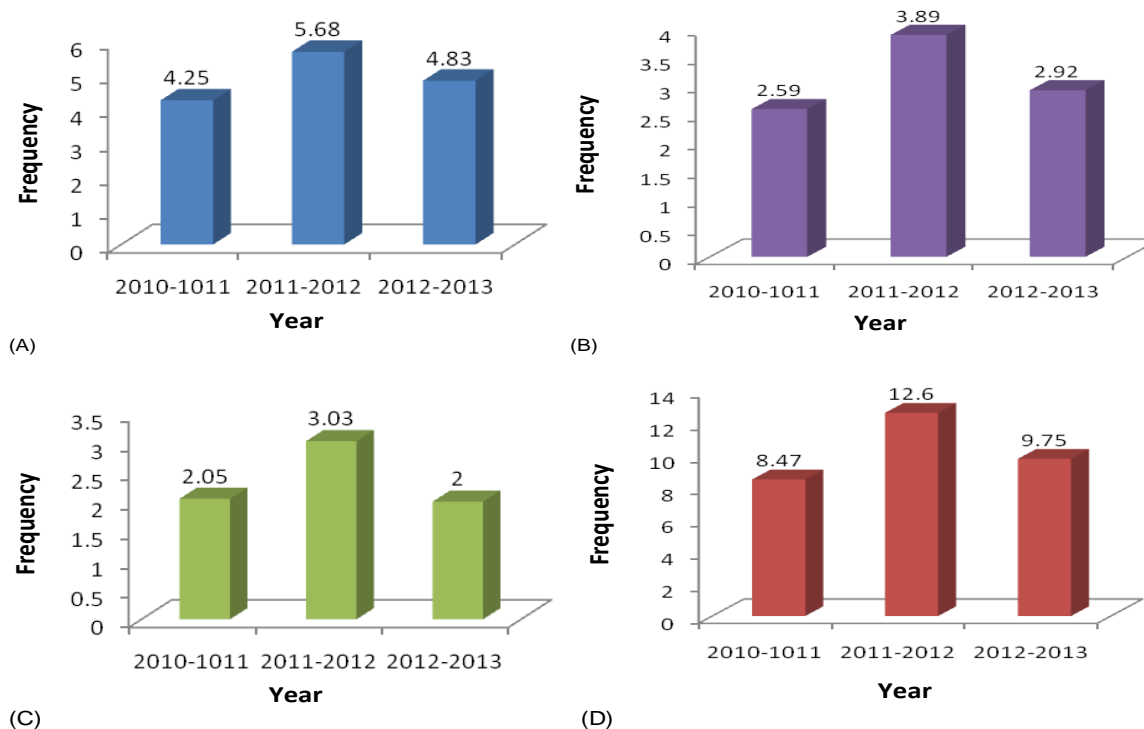
### Study area

The present study area, Kumaun Himalaya (Sub-Himalayan tract of IHR), lies between the altitudes 28° 44' N and 30° 49' and longitudes 78° 45' and 81° 1' E Kumaun, The eastern boarder of the region separates from Nepal by Kali river, High transverse mountain spurs separate it from the Chamoli and Pauri districts of Garhwal, a natural water separates from Tibet and the

southern limit of the Tarai belt demarcates its southern boundary. All the ten selected study sites (Laspa, Burfu, Bilju, Martoli, Ganghar, Milam I, Milam II, Tejam, Shimdum I and ShimdumII) are situated at the higher altitudinal ranges (2780 to 3680 masl) of district Pithoragarh (Figure 1).

### MATERIALS AND METHODS

The surveys were made for three successive years viz., 2009 to 2010, 2010 to 2011 and 2011 to 2012 to record the annual variation in phyto-sociological aspects such as relative values of frequency, density, abundance and IVI for the selected species. For the phyto-sociological study, the area of each and every study site was surveyed extensively and ten populations (7 in Johar valley, 3 in



**Figure 2.** (A) Relative frequency values of *Picrorhiza kurroa* Royle ex Benth. in Successive years, (B) relative density values of *Picrorhiza kurroa* Royle ex Benth. in successive years, (C) relative dominance values of *Picrorhiza kurroa* Royle ex Benth. in successive years and (D) IVI values of *Picrorhiza kurroa* Royle ex Benth. in successive years.

Chaudus valley) were identified (Table 1) on the basis of (a) habitat attribute (altitude), (b) population size and, (c) accessibility for data collection. The herbaceous species was studied by laying 30 quadrats of 1 m × 1 m (1 m<sup>2</sup>) size randomly in each study site (Misra, 1968). The size and the number of quadrats were determined by the species curve (Misra, 1968) and the running means methods (Kershaw, 1973). In each quadrat, trees were recorded with > 31.5 cm cbh (circumference at breast height that is, 1.37 m above the ground). Individuals within the cbh range of 10.5 to 31.4 cm were considered as shrubs + saplings and individuals < 10.5 cm cbh were considered as herbs + seedlings. Individuals of all species were counted in each quadrat. The important quantitative analyses such as density, frequency and abundance of the species were determined as per Curtis and McIntosh (1950). Similarly, relative values of frequency, density, dominance and IVI were calculated following the methods of Curtis (1959). IVI was calculated through the sum of relative frequency, relative density and relative dominance. The threat category of *P. kurroa* Royle ex Benth. was identified using six attributes (that is, habitat preference, distribution range, population size, use pattern, extraction trend, native and endemic species) as per the methods advocated Samant et al. (1998) and Ved et al. (2003). Species with a combination of these criteria (serial number 1, 2 and 3) were given marks accordingly (Table 1).

## RESULTS

In the phyto-sociological survey it was observed that the Kumaun region of Uttarakhand has a rich floristic wealth where many plant species are prevalent in the socio-

consciousness as medicine, fodder, healer etc. In this piece of work *P. kurroa* Royle ex Benth. was investigated from its phyto-sociological perspective in which the  $R_{Fr}$ ,  $R_{Den}$ ,  $R_{Dom}$  and IVI were calculated. This work was done for three successive years viz. 2009 to 2010, 2010 to 2011 and 2011 to 2012 and the data of every year was compared to depict the annual variation in the phyto-sociological status of this plant. The minute observation of the data revealed that the phyto-sociological status of this plant varied to a great extent every year. *P. kurroa* Royle ex Benth. recorded the minimum values in the year 2010 to 2011 (4.25, 2.05, 2.59 and 8.47 for  $R_{Fr}$ ,  $R_{Den}$ ,  $R_{Dom}$  and IVI, respectively), while the values of these parameters were 5.68, 3.03, 3.89 and 12.60 in the year 2011 to 2012 and 4.83, 2.00, 2.92 and 9.75 in 2012 to 2013 (Table 2 and Figure 2A to D).

## Threat categorization

*P. kurroa* Royle ex Benth. is a highly traded medicinal plant species which is used and traded by various pharmaceutical companies. However, due to unscientific harvesting and high anthropogenic pressure the species is facing the risk of extinction. International Union for Conservation of Nature and Natural Resources (IUCN) in 2009 categorized the species as critically endangered

**Table 1.** Threat assessment of the medicinal plant diversity.

S/No	Habitat	Distribution	Population (Ind/location)	Use pattern	Extraction trend	Native and endemic	Score
1	Single	<500	250 Ind/upto 2 locality	4 and >4	Commercial	Native and Endemic	10
2	2-3	500-1000	250–1000 Ind/ 3–5 locality	2-3	Self use	Native/ Endemic	6
3	>3	>1000	1000 Ind/>5 locality	Single	No Use	Non Native	2

**Table 2.** Changes in phyto-sociological aspects of *Picrorhiza kurroa* Royle ex Benth. in the successive years 2010-2013.

Name of Species	Years	R <sub>Fr</sub>	R <sub>Den</sub>	R <sub>Dom</sub>	IVI
	2010-2011	4.25	2.05	2.59	8.47
<i>Picrorhiza kurroa</i> Royle ex Benth.	2011-2012	5.68	3.03	3.89	12.60
	2012-2013	4.83	2.0	2.92	9.75

(CR). From the area, in specific threat categorization of *P. kurroa* done in the present investigation for short and long term management planning following the methods of Samant et al. (1998) and Ved et al. (2003) using six attributes, it was found that the species was vulnerable (VU) in the study area, and therefore, it is necessary to conserve the species through possible viable techniques such as *ex-situ* conservation, *in-situ* conservation or germplasm conservation.

## DISCUSSION

It is clear from the observation that *P. kurroa* Royle ex Benth. had the maximum value in the year 2011 to 2012 which were 5.68, 3.03, 3.89 and 12.60 for relative frequency, relative density, relative dominance and IVI, respectively. These values were found fluctuating in every successive year (Figure 2A to D). So, it becomes evident that the phyto-sociological status of *P. kurroa* Royle ex Benth. varies annually to a great extent. The

threat assessment of the species also shows that the species is getting diminished day by day at higher rate, probably due to climatic and seasonal changes, habitat fragmentation/destruction, over grazing, over exploitation in trade and lack of pollinator in the higher alpine region. To conserve the species, *in-situ* conservation is the best option (Arya et al., 2013). Identification of preferred habitats, altitudinal range and the elite populations with respect to below ground biomass will pave the way for re-introduction of the species. Furthermore, to preserve the important medicinal flora, it is necessary to make the local people aware of the value and use of the plant and restrict over-exploitation of plant species from the natural habitats.

## ACKNOWLEDGEMENT

The authors are thankful to the inhabitants of the study area for their help and support during the tenure of the study.

## Conflict of interests

The author(s) have not declared any conflict of interests.

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*Full Length Research Paper*

## Ethno botany of some selected Monochlamydeae plant species from the Kashmir Himalaya, India

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Received 8 May, 2014; Accepted 18 June, 2014

The strong connecting link between the current loss of medicinal plants/flora and the missing of valuable conventional knowledge associated with the plants suggests a need to conduct ethno-botanical research and to document the medicinal plants and the associated traditional knowledge. Importance of medicinal plants in the traditional health care has now assumed more importance. However, information on the uses of plants for medicine is lacking from many hilly and tribal areas of Kashmir Himalaya. The present study has been carried out from different high altitude areas of Kashmir to look for the diversity of plant resources that are used by local people for curing various ailments. The information has been collected for 16 Monochlamydeae species, of which medicinal uses of 3 species are reported for the first time. It has also been found that most of the species are used for the general health problems and wound healings besides for the treatment of skin, gastric diseases etc.

**Key words:** Ethnobotany, Kashmir Himalaya, traditional knowledge, Monochlamydeae.

### INTRODUCTION

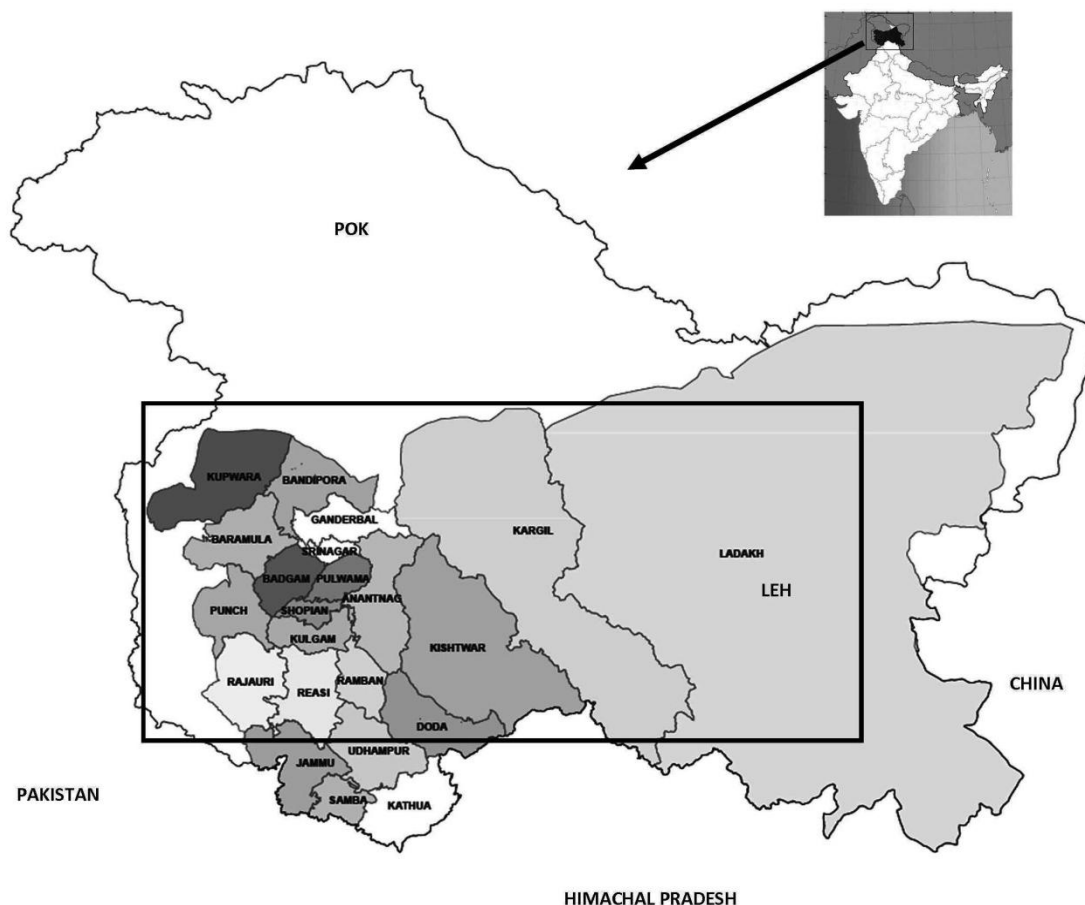
Ethno-botanical information on medicinal plants and their uses by indigenous cultures is useful not only in the conservation of traditional cultures and biodiversity, but also for community health care and drug development. This information is utilized as a guide for drug development under the assumption that a plant which has been used by indigenous people over a long period of time may have an allopathic application (Farnsworth, 1993).

Indigenous knowledge is the main resource of all the ethnobotanical investigations and is generally known as traditional ethnobotanical knowledge. However, the continuation of this knowledge is endangered when

transmission between the older and younger generation is no longer connected (Kargioglu et al., 2008). According to World Health Organization (WHO, 2002), around 75% of the population in the developing countries relies still on traditional system for their primary healthcare needs. From the very earliest days of civilization, mankind has turned to plants for healing, a tradition that has survived the arrival of modern medicine and found new strength at the end of 20th century. Even today 80% of the world population relies on traditional plant medicine (Singh and Verma, 2008). As per Ayurvedic Materia Medica, there is no plant species on earth which is not medicinally important. India is also one of the most important

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**Figure 1.** Map of localities surveyed in Kashmir Himalaya.

medicinal collection centres of the world and about 65% of the population depends on this system (Uniyal and Shiva, 2005). The indigenous medicinal information of plants is helpful to ecologists, pharmacologists, taxonomists and wildlife managers in civilizing the prosperity of area, besides listing the traditional uses (Ibrar et al., 2007).

During the last century, various studies have been carried out to document the ethnobotanical use of plant species growing in the region albeit. Therefore, documentation of the traditional ethnobotanical knowledge through ethnobotanical studies is important for the conservation and utilization of biological resources (Muthu et al., 2006).

### Study area

The study area includes the Kashmir Himalayan region lying across 33 to 36° north latitude and from 72 to 80° east longitude, and occupying an area of approximately 2, 22, 800 km<sup>2</sup> between the altitudes of 1,700 and 5,500 m (a.s.l.) (Figure 1). This part is nestled within North-Western folds of the recently designed global biodiversity

hot spot of the Himalayas (Mittermeir et al., 2005). Owing to the wide altitudinal gradient and varied edapho-climatic and physiographic features, the region harbours wide array of habitats including fresh water alpine lakes, wet lands, springs, ponds, swamps, marshes, glaciers etc. which support equally diverse vegetation types including cultivated pastures and crop fields, plantation stands, orchards, deciduous scrubs, evergreen coniferous forests, subalpine and alpine meadows. Kashmir valley has a treasure house of medicinal plants (Dar et al., 2002). The traditional use of herbs for relieving various ailments has been practiced by the people since time immemorial. Mostly, local herb sellers called "Hakims" have been administering local herbs to people for a number of ailments and thus played a significant role in the health care system. In Ladakh, there is a well known system called Amchi system of Medicine where the local herbs are extensively used for various ailments (Buth and Navchoo, 1988). Some praise worthy contributions with regard to ethnobotanical work from the area include the work carried by Sharma (1991), Singh (1994), Siddique et al. (1995), Kaul (1997), Virendra et al. (2002), Beigh et al. (2003), Ganaie and Nawachoo (2003), Khan et al. (2004), Tantray et al. (2009), Malik et al. (2011) and



**Figure 2.** (a to c) Author documenting ethno-botanical information from local people.

Jeelani et al. (2013). Since most of the medicinal plants are either rare or threatened, need has been felt for the speedy documentation of the prized indigenous knowledge so that proper actions are undertaken to conserve these valuable plant resources.

## METHODOLOGY

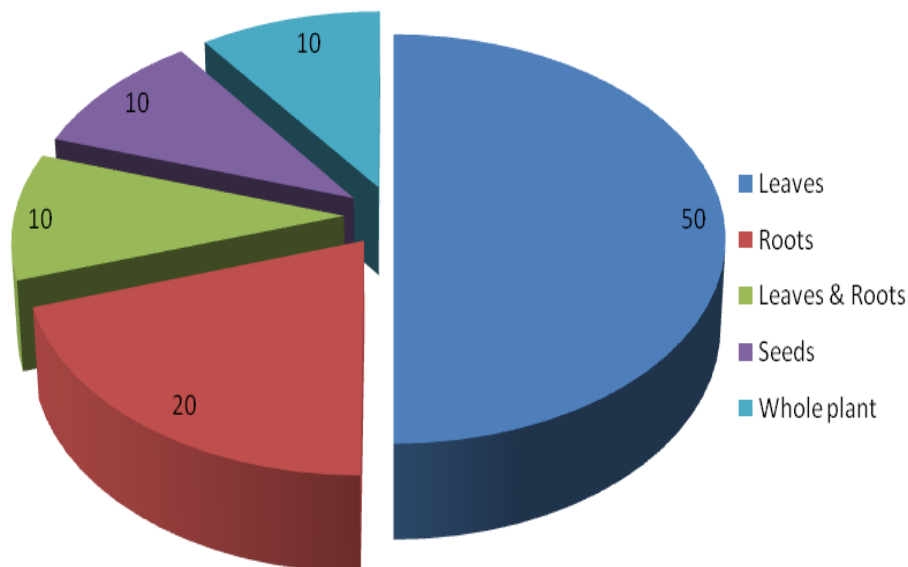
Ethnobotanical information about some of plant species was collected from diverse habitats of study area during regular field trips made from 2008 to 2011. Various tribal people, local people and hakeems of the Kashmir area were interviewed for procuring maximum knowledge regarding the ethnobotanical uses of these plants. Standard method has been used to acquire the ethno medicinal information from these people for authentication purposes (Croom, 1983). During the study, 16 plant species belonging to different families were collected and their ethnobotanical information recorded (Figure 2a to c.). These plant species collected by the author were later identified after consulting the herbarium at University of Kashmir (KASH), Punjabi University, Patiala (PUN), Botanical survey of India (BSI), Northern circle Dehradun and Forest Research Institute Dehradun (FRI). The identified specimens are preserved in the herbarium of the Department of Botany, Punjabi University, Patiala.

## RESULTS

A total of 16 medicinally important plants belonging to 7 different families were reported during this research. Out of these 16 plant species the ethnobotanical information about *Phytolacca acinosa* Roxb., *Rumex dentatus* L. and *Rumex nepalensis* Spreng. are reported for the first time. It has also been observed that most of the species are used for the general health problems and wound healings besides for the treatment of diseases of skin, gastric, etc. In a similar way, the most preferred plant parts for the preparation of such medicines are leaves followed by roots, whole plant, seeds, shoots and grains (Figure 3). The data for each species covers family, botanical name, local name and traditional use as well as preparation are provided in the Table 1.

## DISCUSSION

The present study has reported ethnobotanical uses of 16 species belonging to 7 families of flowering plants inhabiting high altitudinal areas of Kashmir Himalaya. The species are used by local and tribal people in the hilly areas. Majority of the plant species are herbaceous and multiple of home remedies are enjoyed for the treatment of ailments such as fever, headache, constipation as well as skin, gastric diseases. Different plant parts such as roots, leaves, fruits, seeds etc. are used. Both fresh and dried parts of plants are used in crude. However, the methods of use, the dosage and the duration differ from one plant species to another and also from locality to locality. The drugs are mostly prepared in the form of pastes, powder, latex and decoction. Based on the indigenous knowledge collected during the study, it can be seen that the area is a valuable source of medicinal flora with different medicinal properties. In this context, it is important to appreciate that the plant/herbal remedies would be of great therapeutic value for different diseases of humans and domestic animals and offer alternative



**Figure 3.** Frequency of different preferred plant parts for the preparation of medicine. Values are in percentage.

herbal treatments to a broad spectrum drugs. Most of the plants used for different medicinal purposes are regarded as very important and are used extensively. Due to this extensive usage they are over-harvested/over-exploited.

The choice of use for herbs was noticed to be influenced by many factors such as season of the year, accessibility and knowledge of other species. People who lived at lower altitudes of the valley had no easy access to herbs found at higher altitudes such as *Rheum emodi* Wall and *Rheum webbanium* Royle hence their first choice remained the species available in and around their homes. However, people especially tribals who lived at higher altitudes had vast knowledge about these important medicinal plant species used to collect and store them and eventually made available to others residing at lower altitudes. Results revealed that a major proportion (75%) of folk medicinal knowledge came from people above the age of 55 years, while a small proportion (25%) of it came from people between the ages of 37 and 50. This result is in accordance with the earlier findings (Hamayun et al., 2006).

Gender wise, men especially old ones had more traditional knowledge about medicinal plants and their uses than females. This may be attributed to two reasons. Firstly because of the involvement of males in collection and trade related activities. Secondly higher reaches had been under seize of security forces since decades in response to terrorist threats thus posing biggest hindrances in the movement of women (Lone et al., 2013). Informants below the age of 50 years were reported less aware of the potential of medicinal plants than their older counterparts who had gathered knowledge from the point of view of their traditional healthcare

and their day to day practices. The differences in the perception of the two age classes will likely result in knowledge loss over time.

Since, in the present study, it was noticed/investigated that the majority of the species were collected from the wild sources, it is a well known fact that the wild populations of medicinal plants are the main sources of raw materials to the pharmaceutical industries. In Kashmir valley various factors that are considered as main threats to medicinal plants were recorded by interviewing the informants. The major factors claimed were increasing population of the area, over-grazing by animals, deforestation, agricultural expansion, lack of job opportunities, increased marketing pressure, trading of charcoal and firewood and indiscriminate harvesting by unskilled gatherers.

There is no immediate conservation programme for this valuable source of medicinal flora. The local Hakims pay a few rupees to local people to collect the plants for them. It has been observed that some plants (*R. emodi* L. and *R. webbanium* Royle) are already on the endangered list (Saggoo and Farooq, 2011) and to prevent their extinction, efforts need to be made with a view to protect these important plant species by initiating conservation practices, cultivation programme, scientific harvest and research institutes which lead from folklore and develop medicine on scientific basis. Besides, giving conservation priority for identified threatened medicinal plants, promoting *in-situ* and *ex-situ* conservation of medicinal plants in the study area by providing funds, land for cultivating medicinal plants and assisting their activities with professional guidance will definitely help in conserving the medicinal plants of the study area.



**Table 1.** Ethnobotanical information about some plants belonging to group Monochlamydeae from Kashmir Himalaya.

S. No	Botanical name / Local name	Part used	Uses / mode of administration
1	<i>Amaranthus caudatus</i> L. Kashmiri: Lessa	Leaves	The extract of leaves and inflorescence are used against high fever. The herb is also used vegetable. The extract of 5-6 ml is given early in the morning for 2-3 weeks
2	<i>Chenopodium album</i> L. /Janchikarpo, Saag	Leaves	Leaves are boiled in water and cooled over night and used against gastric trouble. An extract from the seeds acts as diuretic. Leaves used as vegetable
3	<i>C. botrys</i> L. Kashmiri: Kulkuli akh	Leaves	The extract is prepared, used against Asthma, extract of 2-6ml twice a day till recovery from disease. Also taken as vegetable to cure the disease
4	<i>Cannabis sativa</i> L. Kashmiri: Bhang	Leaves	Dried leaf powder is mixed with egg yolk then cooked to form an omelette. It is used to check night urination in children
5	<i>Euphorbia helioscopia</i> L. Kashmiri: Guri Sochol	Leaves	Leaves and stem latex are used against ringworm infection
6	<i>Euphorbia wallichii</i> Hook. f Kashmiri: Guri-dud	Leaves	Purgative and digestive. The juice obtained from the plant is applied to warts and skin infection
7	<i>Fagopyrum tataricum</i> (L.) Gaertn Kashmiri: Trumba	grains	Grain obtained for human consumption and is also grown for live stock and poultry feed, as green manure and is excellent crop for soil improvement
8	<i>Oxyria digyna</i> Hill Kashmiri: Chumcha	Leaves/Shoots	In Ladakh, The shoots are kept in luke warm water and taken in the morning as an appetizer. The Gujar and Bakerwals consume it as vegetable
9	<i>Phytolacca acinosa</i> Roxb. Kashmiri: Kafal/Hapath watch Gogri: Totorow/ Hapath chuiiri	Roots/seeds	The root is cut into small pieces and dried. 1-2g root powder in hot water twice a day used against stomach cramps, dysentery and wounds. Dried roots are mixed with warm mustard oil and applied in ailing joints. Seeds are sold in large quantity
10	<i>Rheum emodi</i> Wall. Kashmiri: Pumba chalan ( <i>critically endangered</i> )	Roots	The root is powdered in to fine paste and used against Rheumatic pain, wounds. The powder of 3-5 g once in a week with milk. The paste is applied on affected portion externally. In Ladakh, leaf stalks, leaves and flowers are consumed after cooking
11	<i>Rheum webbianum</i> Royle. Kashmiri: Pumba chalan Ladakhi: Latchu ( <i>critically endangered</i> )	Roots/leaves	The root is powdered in to fine paste and used against Rheumatic pain, wounds. In Ladakh, the leaves are useful in controlling piles, chronic bronchitis
12	<i>Rumex acetosa</i> D.Don. Kashmiri: Abjie	Whole plant	Used against hardness of muscles, asthma and skin diseases. It is used as a vegetable in juvenile stage by the Gujar and Bakerwals. The plants is dried and crushed to make the powder which is mixed with oil or ghee to make paste. Sometimes the herb is crushed and the extract is obtained. The extract of 5-10ml is given twice a day. The paste is applied on the affected portion externally
13	<i>Rumex dentatus</i> L. Kashmiri: Abjie Gogri: Holla Ladakhi: Shoma	Leaves/roots	Extracts of the roots taken in the quantity of two spoons in a cup of tea daily for 15-days for curing constipation
14	<i>Rumex hastatus</i> Kashmiri: Sozk scai	Leaves	Used as vegetable by the Gujar and Bakerwals

Table 1. Contd.

15	<i>Rumex nepalensis</i> Spreng. Kashmiri: Abjie Gogri: Holla Ladakhi: Shoma	Whole plant	In Ladakh, it is used as a fodder. Its dried parts are used as a remedy for pain. The Gujar and Bakerwals extract the juice from the plant and use it against jaundice. While as the local people rub it to undo the effect of <i>Urtica dioica</i> .
16	<i>Urtica dioica</i> L. Kashmiri: Soi	Roots	Roots are made in to fine paste in oil and used to heal up minor wounds. It is also used to treat cysts of feet and hands.

## ACKNOWLEDGMENT

The authors are grateful to the Director Botanical Survey of India (BSI) Dehradun India in identifying the plant specimens. The authors are equally pleased to put on record the help from tribals and Hakims in documenting the traditional knowledge. Thanks are also to the Head Department of Botany, Punjabi University Patiala for necessary facilities.

## Conflict of Interests

The author(s) have not declared any conflict of interests.

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*Full Length Research Paper*

## Research on herbal combinations of traditional Chinese medicine for chronic gastritis based on network biology

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Received 4 March, 2011; Accepted 19 December, 2011

**Herbal combinations are important for traditional Chinese medicine physicians to treat diseases. Based on Professor GAO Zhongying's medical records, combination laws are explored in order to study and inherit Professor GAO's academic thoughts and improve the level of clinical treatment from multiple perspectives in treating chronic gastritis. Based on an entropy clustering method of complex systems, Professor GAO's formula data is mined to draw the combinations which have good effects on the treatment of chronic gastritis. Meanwhile, the software Pajek developed for complex network was applied in the process. It not only provides a group of fast and efficient algorithms to analyze complex networks, but also presents a visual interface to facilitate the understanding on the structural characteristics of complex networks from a visual point of view. Through analyzing the commonness of Professor GAO's formulas, we found the compatibility structure that reflected formula thinking and core clinical features, and supported the arrangement of Professor GAO's experiences. Through the procedure mentioned mentioned, we analyzed and screened 730 formulas in the database, and found 30 herbs most frequently used in the treatment of chronic gastritis. By applying the measure of modified mutual information, we got 94 commonly-used herbs with correlation coefficients above 0.05; and through the entropy clustering method of complex systems, we found 11 core combinations. The entropy clustering method of complex systems was used to build the association among 80 herbs commonly used to treat chronic gastritis, and then 122 associations were obtained. We draw out the complex network graph of herbs commonly used for chronic gastritis. These results are completely in line with clinical practices, and they are essentially the commonly used herbs employed by Professor GAO Zhongying for chronic gastritis.**

**Key words:** Herbal combination, chronic gastritis, entropy clustering of complex systems, complex network.

### INTRODUCTION

Chronic gastritis is caused by different chronic inflammations of gastric mucosa or atrophic lesions. Besides, chronic gastritis is one of the most common digestive diseases; its incidence rate is the highest

among the various types of stomach diseases, to account about 80 to 90% of gastroscopy patients. Chronic gastritis is usually divided into chronic superficial gastritis (CSG) and chronic atrophic gastritis (CAG). CSG is caused by a

variety of chronic inflammation of gastric mucosa superficial, more abdominal pain, fullness after eating, loss of appetite and belching and other bits main symptoms. Unfortunately, there is no effective therapy for CSG in modern medicine. According to the taxonomy in Traditional Chinese Medicine, CSG belongs to stomach swelling of the liver, stomach category in Traditional Chinese Medicine. On the other hand, CAG is a gastric glands atrophy, mucosal thinning, or with intestinal metaplasia, dysplasia of the pathological features of digestive diseases (Digestive Disease Branch of Chinese Medical Association, 2006).

In Western medicine, there exist many treatments including the general, Hp eradication, mucosal protective agent, acid, acid-suppressing agents, prokinetic agent therapies and so on for chronic gastritis. The treatment method for Hp-related gastritis has a first-line therapy, second-line treatment, re-called remedial treatment, and sequential therapy. In Traditional Chinese Medicine, treatment of chronic gastritis achieves a good effect. However herbal combination laws play an essential role in the process of therapy. Therefore, the current research on chronic gastritis is focused to select the appropriate methodology to discover the herbal combination laws.

Complex network is one of the methods of data mining which discovers the potential value of the relationship between decision-making, patterns and trends from a large amount of implicit, previously unknown data (Chen et al., 2007). In many cases, data mining is essential to accidentally discover unexpected and valuable knowledge. In recent years, complex network is in the stage of development, and models of complex network have been applied in many fields of natural and social sciences. Complex network can be used to describe the social relations among people, the prey species relationships, the topological structures of computer network, semantic relations of words, cooperative relationships of scientists, interactive relations of protein effect, reference relationships of scientific research articles, link relations of webs, and so on. In conclusion, complex network is used widely from World Wide Web and social network to the food chain and neural system of organisms. Now, complex network of qualitative and quantitative study of science has become a major trend. Although the types of complex network are vastly different, we can use a common model called graph theory to characterize their shared feature. Compared with the complexity of general graph, complex network has a large number of nodes and edges. Therefore, effective and efficient software is required to analyze and simulate complex networks. Pajek can be used for realizing the functions of complex network (Batagelj and

Mrvar, 2003). Pajek, which means spider in Slavic, not only provides a group of fast and efficient algorithms for analysis of complex networks, but also provides a visual interface that can be more intuitive from a visual point of view to understand the structural characteristics of complex networks. Pajek has a quick calculation, simple visualization and abstract features (Hopkins, 2008; Shi et al., 2010).

Professor GAO Zhongying has 58 years of experience in clinical medicine, teaching and research work and especially has a great contribution to apply Chinese medicine to treat chronic gastritis. In order to study and inherit Professor GAO's academic thoughts, and improve the level of clinical treatment, his clinical medication laws are summarized and investigated in treating chronic gastritis from multiple perspectives. By means of entropy clustering method of complex systems and complex network, Professor Gao's formula data is mined, and afterwards we explored the laws of herbal combination in formulas which have good effects in the treatment of chronic gastritis.

## MATERIALS AND METHODS

### Clinical data

All the medical records of chronic gastritis were collected from Professor GAO Zhongying's recipes in the Dashanlan Clinic and the Dongshi Tenth Road Clinic of Beijing Tong Ren Tang, and the Famous Physician Clinic of Gulou TCM Hospital from March, 2008 to July, 2009. Totally, 730 records were included and all the cases meet the diagnostic criteria for chronic gastritis stipulated in the Guiding Principles of Clinical Studies of New Chinese Drugs in 2002. All the patients were diagnosed as chronic gastritis by measures of endoscopy or biopsy in first class hospitals. In totality, there are 416 chronic superficial gastritis cases and 314 chronic atrophic gastritis cases. The distributions of age and gender are shown in Table 1.

### The construction of prescription database

It is necessary to standardize prescription information in order to meet the requirements of data mining. Firstly, the medical named entities of symptoms, signs, and checked terms are unified to create the related term specification. Secondly, the terms of diagnosis, syndromes, and therapies are standardized by means of unifying, summarizing, and splitting into relatively independent evidences of the meaning of elements in accordance with unified textbooks, and finally the related database is created. Thirdly, herbal names are unified by the way of summarizing their categories, functions, natures, flavors and channel tropisms according to the current 21st century curriculum materials. Based on Access database, the structural medical record template is built for Professor GAO Zhongying clinical diagnosis. The patient

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**Table 1.** Distributions of age and gender.

Type	Frequency	Male	Female	Age
CSG	416	169	247	45.25±7.8
CAG	314	130	184	48.50±8.6

information was written into the database in accordance with national standard format. Detailed records of 730 patients were enrolled into Professor GAO Zhongying medical records database in order to discover the knowledge based on entropy clustering method of complex systems and complex network.

### Method of data mining

Entropy clustering of complex systems is proposed to mining valued knowledge from formulas. Formula laws can be drawn from the three aspects. The first aspect is referred to the single herb, and it was mainly achieved through the frequency method; the second aspect is referred to the analysis on couplet herbs, mainly through mutual information and association rules, etc., to discuss the commonly used couplet herbs for spleen and stomach diseases; and the last aspect is referred to the combination laws of many herbs, which were discussed through the entropy clustering of complex systems. These three aspects mutually supplemented and corresponded with each other, revealing Professor GAO Zhongying's formula laws together (Shi et al., 2010). The formula database is mined from the multi-levels and multi-dimensions perspectives so that single herb, couplet herbs and many complex herbs are picked up. Compared with the traditional mutual information, the modified mutual information can differentiate positive correlation and negative correlation, and express more positive correlation between couplet herbs. The core thought is to relatively punish couplet herbs occurred in formulas. Thus, the information, that the original positive couplet herbs are not lost and the negative couplet herbs are deleted, ensures the efficacy of mining. The principle of modified mutual information is as follows:

Suppose  $n$  herbs are expressed with  $X_1, X_2, \dots, X_i \dots X_n$  in which  $X_i$  is expressed by  $X_i = (x_i^1, x_i^2, \dots, x_i^j, \dots, x_i^m)$ . And the probability density functions of herbal  $X_i$  are respectively  $p(x_i^1), p(x_i^2), \dots, p(x_i^j), \dots, p(x_i^m)$ , the joint probability distribution density functions of  $X_i$  and  $X_j$  are respectively  $p(x_i^1, x_j^1), p(x_i^2, x_j^2), \dots, p(x_i^k, x_j^k), \dots, p(x_i^m, x_j^m)$  respectively. Shannon entropy of  $X_i$  is shown as formula (1):

$$H(X_i) = \sum_{k=1}^m p(x_i^k) \log(p(x_i^k)) \quad (1)$$

The joint entropy is expressed as formula (2):

$$H(X_i, X_j) = \sum_{k=1}^m \sum_{l=1}^m p(x_i^k, x_j^l) \log(p(x_i^k, x_j^l)) \quad (2)$$

The mutual information between  $X_i$  and  $X_j$  is defined as formula (3):

$$I(X_i, X_j) = H(X_i) + H(X_j) - H(X_i, X_j) \quad (3)$$

This formula can be equal to formula (4):

$$\begin{aligned} I(X_i, X_j) &= H(X_i) + H(X_j) - H(X_i, X_j) \\ &= H(X_i) - H(X_i | X_j) \end{aligned} \quad (4)$$

Formula (4) depicts the correlations between two herbs, but it could not distinguish positive correlation and negative correlation. Therefore, modified mutual information has been proposed to resolve this problem. Positive-correlative herbs or negative-correlative herbs can be differentiated by using the positive occurrence rate (Chen et al., 2007). The positive occurrence rate is referred to the probability when two variables are 0 at the same time. The positive occurrence rate between positive-correlative herbs is very large, while the occurrence rate between negative-correlative herbs should be 0 theoretically, that is, it is impossible that there are two negative-correlative herbs in a formula at the same time. So, the definition of mutual information and correlation coefficient are anew expressed as:

$$\Delta\mu(X_i, X_j) = \begin{cases} \frac{H(X_i) + H(X_j) - H(X_i, X_j)}{H(X_j)} & Po(i, j) \geq \delta \\ \frac{H(X_i) + H(X_j) - 2H(X_i, X_j)}{H(X_j)} & Po(i, j) < \delta \end{cases} \quad (5)$$

Based on entropy clustering of complex systems, correlation coefficients of herbs are computed by the way of the modified mutual information and the modified mutual information can define positive-correlative herbs and belong to the convergence of the proposed clustering principle to summarize three-three relevant from two-two positive correlation. The clustering is performed with a fast convergence while the number of classes is not set.

### Construction of Chinese herbal complex network

Chinese herbal complex network is constructed by Pajek. This software not only provides a group of fast and efficient algorithms for analysis of complex networks, but also presents a visual interface to facilitate the understanding on the structural characteristics of complex networks from a visual point of view. Through the analysis on the commonness of Professor GAO Zhongying's formulas, we found the compatibility structure that reflected formula thoughts and core clinical features, thus supporting the arrangement of Professor GAO Zhongying's experiences. Complex system entropy clustering method is used to build 80 associations between herbs of Chinese medicine treatment of chronic gastritis, and 122 associations are achieved. These data are transformed to the adjacency matrix and this matrix is converted into Pajek format required. Node degrees and edge weights are computed separately by using Pajek 2.0. Node degree is a most simple but most important property in the complex network node properties. The degree of a node is defined as the number of nodes connected to it. Therefore, from an intuitive point of view, the greater the degree of a node indicates that the node is more

**Table 2.** The frequency of herbs.

Index	Herb	Frequency
1	OS swpiae (OS SEPIAE)	355
2	Trichosanthes	347
3	Pseudostellaria heterophylla	324
4	Thunberg fritillary	300
5	Largehead Atractylodes Rh	296
6	Fermented Pinellia	244
7	Rhizoma Zedoariae	201
8	Gallus gallus domesticus Brisson	196
9	Amomum villosum	144
10	Semen Raphani	142
11	Root of Herbaceous Peony	126
12	Rhizoma Coptidis	125
13	Medicinal Evodia Fruit	116
14	Rhizoma Zingberis Preparata	94
15	Endothelium Corneum Gigeriae Galli	80
16	Radix codonopsis	76
17	Semen Arecae Preparata	74
18	Angelica	71
19	Fructus Aurantii Immaturus	67
20	Ophiopogon japonicus	61
21	Immature Trifoliolate-orange Fruit	60
22	Cortex Magnoliae Officinalis	59
23	Bulbus fritillariae cirrhosae	57
24	Elecampane	52
25	Salvia Miltiorrhiza	51
26	Angelica dahurica	47
27	Baikal Skullcap Root	47
28	Dioscorea opposita	44
29	Radix Curcumae	44
30	Rehmanniae (raw)	38

important. Using Pajek2.0 Software Layout-Energy-Kamada-Kawai-Separate-Compinents command, the different types of nodes map can be drawn out, combined with manual operation of the node to mediate.

## RESULTS

Through analyzing the screened 730 prescriptions from database, thirty most frequent herbs are got to use for chronic gastritis after 730 prescriptions were analyzed to screen the database. Thirty herbs are shown in Table 2. Based on the modified mutual information, 94 common herbal pairs are obtained and their correlation coefficients are above 0.05. Results are shown in Table 3. 11 core herbal combinations are achieved by using complex system entropy clustering methods, and these results are shown in Table 4. Based on the results of entropy clustering, herbal complex network is constructed by Pajek. It is shown is Figure 1.

## DISCUSSION

### Results of entropy clustering of Complex systems

Formula in TCM was found to be effective in treating disease (Jianxin et al., 2011a; Jianxin et al., 2011b). The mining of its herbal combination rules play a key role in understanding its action mechanism. Traditional statistics and data mining methods are hardly used to make a distinction between positive correlation and negative correlation because Chinese medicine prescriptions often have the characteristics of high dispersion degree and nonlinear and so on (Jianxin, 2010). The complex system entropy clustering method is proposed to be appropriate for data characteristics of TCM clinicals four diagnostic methods and Chinese medicine prescriptions. It is a kind of unsupervised data mining methods and accords with the non-linear relation among the graded variable such as four diagnostic information. And the variables are clustered by self-organization, and the variable number in each cluster is automatically determined.

Through the methods mentioned, we analyzed and screened 730 formulas in the database, and found most frequent 30 herbs used in the treatment of chronic gastritis. By applying the method of modified mutual information, we got 94 commonly-used herbs with correlation coefficients of above 0.05; and through entropy clustering method of complex systems, we found 11 core combinations. Entropy clustering method of complex systems was used to build the associations among 80 herbs commonly used to treat chronic gastritis, and 122 associations were obtained. We draw out the classified graph of complex network of herbs commonly used for chronic gastritis. According to statistics, cuttlebone had the highest frequency of OS swpiae (OS SEPIAE)355, Radix Trichosanthis 347, Heterophylla falsestarwort 324, Thunberg fritillary 300, Largehead Atractylodes Rh 296, Fermented Pinellia 244, Rhizoma Zedoariae 201, Gallus gallus domesticus Brisson 196, Amomum villosum 144, Semen Raphani 142, Root of Herbaceous Peony 126, Rhizoma Coptidis 125, Medicinal Evodia Fruit 116, Rhizoma Zingberis Preparata 94, Endothelium Corneum Gigeriae Galli 80. The results completely conform to clinical practice, and they basically are the common herbs for treatment of chronic gastritis, which basically uniform with core combination data reflected in Table 3. And they are essentially Professor GAO Zhongying's commonly used herbs for chronic gastritis.

### Results of complex network

Complex network is an effective method to associate diverse kinds of information. The core prescription combinations are selected to reflect the experiences of famous physicians by means of analyzing the graph structures of entropy clustering result.

**Table 3.** Couple-herb and its correlation coefficient.

Index	Couple-herb	Mutual information
1	Rhizoma Coptidis, Medicinal Evodia Fruit	0.64031
2	OS swpiae(OS SEPIAE), Thunberg fritillary	0.19216
3	Endothelium Corneum Gigeriae Galli, Radix Trichosanthis	0.17318
4	Trichosanthes,OS swpiae(OS SEPIAE)	0.14874
5	Tortoise Shell,Drgonsbones	0.14749
6	Tortoise Shell,Oyster	0.14749
7	Lignum Dalbergiae Odoriferae, Kaempferia galanga	0.13394
8	Semen Arecae Preparata,elecampane	0.13394
9	Rhizoma Zingberis Preparata, Amomum villosum	0.12569
10	Largehead Atractylodes Rh,Rehmanniae(raw)	0.11946
11	Largehead Atractylodes Rh,Baikal Skullcap Root	0.11214
12	Milkvetch root,Pseudostellaria heterophylla	0.11102
13	Rehmanniae (raw), Rehmanniae (prepared )	0.10788
14	Rehmanniae(raw), Baikal Skullcap Root	0.10051
15	Angelica,Endothelium Corneum Gigeriae Galli	0.096696
16	Angelica,angelica dahurica	0.096696

**Table 4.** The core herbal combinations.

Index	Herbal combinations
1	Pseudostellaria heterophylla, Largehead Atractylodes Rh, OS swpiae (OS SEPIAE), Thunberg fritillary,Trichosanthes
2	Pseudostellaria heterophylla, Largehead Atractylodes Rh, Endothelium Corneum Gigeriae Galli, Trichosanthes, Thunberg fritillary
3	OS swpiae (OS SEPIAE), Thunberg fritillary, Rhizoma Coptidis, Medicinal Evodia Fruit
4	angelica dahurica, Lignum Dalbergiae Odoriferae, Elecampane, Kaempferia galanga
5	Endothelium Corneum Gigeriae Galli, OS swpiae (OS SEPIAE), Rhizoma Coptidis, Medicinal Evodia Fruit
6	Trichosanthes, OS swpiae (OS SEPIAE), Rhizoma Coptidis, Medicinal Evodia Fruit
7	Thunberg fritillary, OS swpiae (OS SEPIAE), Trichosanthes
8	Largehead Atractylodes Rh, Rhizoma Zedoariae, Pseudostellaria heterophylla
9	Largehead Atractylodes Rh, Baikal Skullcap Root, Pseudostellaria heterophylla
10	Fermented Pinellia.OS swpiae (OS SEPIAE), Trichosanthes
11	Endothelium Corneum Gigeriae Galli, OS swpiae (OS SEPIAE), Trichosanthes

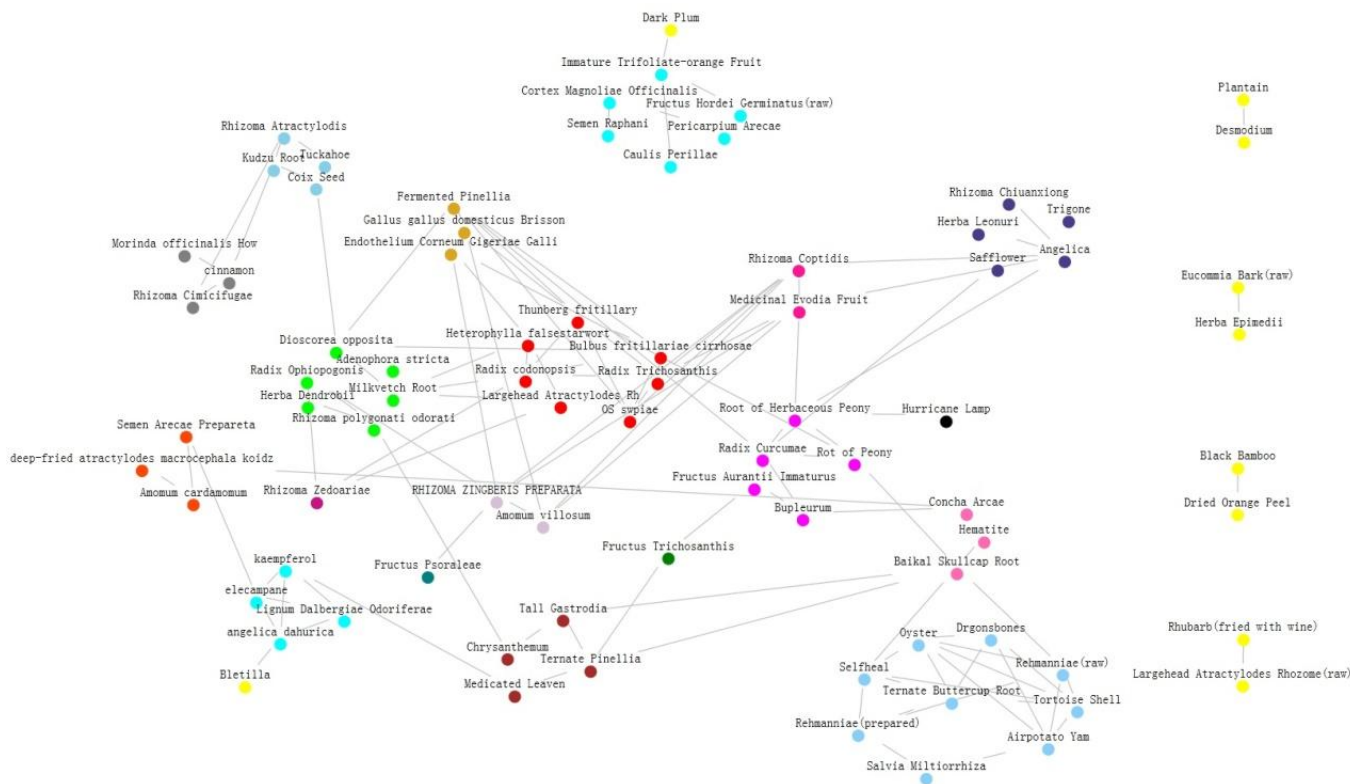


Figure 1. Herbal complex network node categories for chronic gastritis

**The major core herbal combination in complex network**

The major herbal combination has Heterophylla falsestarwort (Radix codonopsis), Largehead Atractylodes Rh, Radix Trichosanthis, Thunberg fritillary (Bulbus fritillariae cirrhosae), OS swpiae (OS SEPIAE). Largehead Atractylodes Rh is mainly used to maintain spleen; Radix Trichosanthis, Thunberg fritillary (Bulbus fritillariae cirrhosae), OS swpiae (OS SEPIAE) are used to repair erosions of stomach. The compatibility of core herbal combination reflects the key pathogenesis of spleen deficiency and stomach dryness for chronic gastritis. Compatibility mechanism of the herbal combination shows the core pathogenesis of spleen deficiency and stomach dry for chronic gastritis. This combination can be used either for chronic superficial gastritis or chronic atrophic gastritis.

**The secondary core herbal combinations in complex network**

The secondary core herbal combinations surround the major core herbal combination in complex network. These combinations are categorized in four groups. The first group is Zuojin pill composed of Medicinal Evodia

Fruit and Rhizoma Coptidis and its function is to treat heartburn, acid reflux embolism. Endothelium Corneum Gigeriae Galli, Fermented Pinellia and Gallus gallus domesticus Brisson can be added in order to promote gastric motility to help to digest. This five herbs combination can be used to cure spleen deficiency and stomach dry of chronic superficial gastritis or gastroesophageal reflux disease. The second group is Sini powder composed of Bupleurum, Radix Curcumae, Rot of Peony, Root of Herbaceous Peony and Fructus Aurantii Immaturus. It has the efficacy of liver and gallbladder. In clinical treatment, it is used for incompatibility of liver and stomach, incompatibility of gall bladder and stomach such as cholecystitis. The third group is Zhang Xichun's Yuye soup which is composed of Adenophora stricta, Ophiopogon japonicus, Rhizoma polygonati odorati, Dioscorea opposita, Herba Dendrobii and Milkvetch root. Its core functionality is to strengthen spleen, invigorate Qi, stomach and promote fluid. This combination can be used to cure spleen deficiency and stomach dry of chronic superficial gastritis. With intestinal metaplasia or dysplasia, Salvia Miltiorrhiza and Rhizoma Zedoariae must be added to promote blood circulation and remove stasis. The fourth group includes Rhizoma Zingiberis Preparata and Amomum villosum. It is used to cure hypofunction of Yang and deficiency and coldness of spleen. With diarrhea, Fructus Psoraleae, Gorgon fruit



and Lotus meat must be added.

### Basic experience prescription of chronic gastritis

Combining the result of complex network with clinical practice, experience formula is summed up as follows:

(1) The basic formula for chronic superficial gastritis include *Heterophylla falsestarwort* (*Radix codonopsis*), *Largehead Atractylodes* Rh, *OS swpiae* (*OS SEPIAE*), *Thunberg fritillary* (*Bulbus fritillariae cirrhosae*), *Radix Trichosanthis*, *Gallus gallus domesticus* Brisson, *Endothelium Corneum Gigeriae Galli* and *Fermented Pinellia*.

(2) The basic formula for chronic atrophic gastritis include *Heterophylla falsestarwort* (*Radix codonopsis*), *Largehead Atractylodes* Rh, *OS swpiae* (*OS SEPIAE*), *Thunberg fritillary* (*Bulbus fritillariae cirrhosae*), *Radix Trichosanthis*, *Adenophora stricta*, *Ophiopogon japonicas*, *Rhizoma polygonati odorati*, *Dioscorea opposita*, *Herba Dendrobii* and *Milkvetch root*.

(3) Basic formula addition and subtraction herbal laws: The prescription adds *Medicinal Evodia Fruit* and *Rhizoma Coptidis* accompanying with gastroesophageal reflux. If this reflux becomes severe, *Concha Arcae*, *Inula flower* and *Hematite* are added into this formula. If erosion or ulceration of stomach appears, *Bletilla* and *Angelica dahurica* are added, and *Bupleurum*, *Radix Curcumae*, *Fructus Aurantii Immaturus* (Immature *Trifoliolate-orange Fruit*) and *Root of Herbaceous Peony* are added when bile reflux. *Rhizoma Zingiberis Preparata* and *Amomum villosum* are added if stomach cold becomes severe and pale tongue appears. *Fructus Psoraleae*, *Gorgon fruit* and *Lotus meat* are added if diarrhea appears.

### CONCLUSION

Herbal combination laws are essential to treat the diseases for traditional Chinese medicine. In this paper, we explore Professor GAO Zhongying' experiences that they are reflected in his formulas of the treatment for chronic gastritis. And then entropy clustering and complex network are adopted in the process of discovering knowledge of herbs. The results show that herbal combinations are completely in line with clinical practices, and they are essentially the commonly used herbs employed by Professor GAO Zhongying for chronic gastritis.

### ACKNOWLEDGEMENTS

This work was supported by the National Science Foundation of China (30902020, 81173463 and 61003133).

### Conflict of Interests

The author(s) have not declared any conflict of interests.

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