International Journal of Pure and Applied Mathematics
Volume 99 No. 4 2015, 477-486
ISSN: 1311-8080 (printed version); ISSN: 1314-3395 (on-line version)
**url:** http://www.ijpam.eu
**doi:** http://dx.doi.org/10.12732/ijpam.v99i4.8
ijpam.eu

# SOME FIXED POINT THEOREMS FOR MAPPINGS ATISFYING CONTRACTIVE CONDITIONS OF INTEGRAL TYPE IN MODIFIED INTUITIONISTIC UZZY METRIC SPACES

Saurabh Manro[1], Shin Min Kang[2 §]

[1]School of Mathematics and Computer Applications
Thapar University
Patiala 147004, Punjab, INDIA
[2]Department of Mathematics
Research Institute of Natural Science
Gyeongsang National University
Jinju, 660-701, KOREA

**Abstract:** In this paper, we prove some common fixed point theorems for occasionally weakly compatible mappings satisfying contractive conditions of integral type in modified intuitionistic fuzzy metric spaces.

**AMS Subject Classification:** 47H10, 54H25
**Key Words:** modified intuitionistic fuzzy metric space, occasionally weakly compatible mapping, common fixed point

## 1. Introduction

Atanassove [2] introduced and studied the concept of intuitionistic fuzzy sets as a generalization of fuzzy sets.

In 2004, Park [9] defined the notion of intuitionistic fuzzy metric spaces with the help of continuous $t$-norms and continuous $t$-conorms.

Received: December 26, 2014



§Correspondence author

Recently, in 2006, Alaca et al. [1] using the idea of intuitionistic fuzzy sets, defined the notion of intuitionistic fuzzy metric spaces with the help of continuous $t$-norm and continuous $t$-conorms as a generalization of fuzzy metric space due to Kramosil and Michálek [8]. In 2006, Türkoğlu et al. [13] proved Jungck's common fixed point theorem ([6]) in the setting of intuitionistic fuzzy metric spaces for commuting mappings. In 2006, Gregori et al. [5] showed that the topology induced by fuzzy metric coincides with topology induced by intuitionistic fuzzy metric.

In view of this observation, Saadati et al. [11], in 2008, reframed the idea of intuitionistic fuzzy metric spaces and proposed a new notion under the name of modified intuitionistic fuzzy metric spaces with the help of the notion of continuous $t$-representable.

In this paper, we prove some common fixed point theorems for occasionally weakly compatible mappings satisfying contractive conditions of integral type in modified intuitionistic fuzzy metric spaces.

## 2. Preliminaries

**Definition 2.1.** ([4]) A triangular norm ($t$-norm) on $L^*$ is a mapping $\Im : (L^*)^2 \to L^*$ satisfying the following conditions: for all $x, x', y, y', z \in L^*$,

(i) $\Im(x, 1_{L^*}) = x$ (boundary condition);

(ii) $\Im(x, y) = \Im(y, x)$ (commutativity);

(iii) $\Im(x, \Im(y, z)) = \Im(\Im(x, y), z)$ (associativity);

(iv) If $x \leq_{L^*} x'$ and $y \leq_{L^*} y'$, then $\Im(x, y) \leq_{L^*} \Im(x', y')$ (monotonicity),

where $L^* = \{(x_1, x_2) : (x_1, x_2) \in [0, 1]^2 \text{ and } x_1 + x_2 \leq 1\}$ and for every $(x_1, x_2)$ and $(y_1, y_2) \in L^*$, $(x_1, x_2) \leq_{L^*} (y_1, y_2)$ if and only if $x_1 \leq y_1$ and $x_2 \geq y_2$.

We denote its units by $0_{L^*} = (0, 1)$ and $1_{L^*} = (1, 0)$.

**Definition 2.2.** ([4]) A continuous $t$-norm $\Im$ on $L^*$ is called *continuous $t$-representable* iff there exists a continuous $t$-norm $*$ and a continuous $t$-conorm $\diamond$ on $[0, 1]$ such that for all $x = (x_1, x_2)$ and $y = (y_1, y_2) \in L^*$, $\Im(x, y) = (x_1 * y_1, x_2 \diamond y_2)$.

**Definition 2.3.** ([11]) Let $M, N$ are fuzzy sets from $X^2 \times (0, \infty)$ to $[0, 1]$ such that $M(x, y, t) + N(x, y, t) \leq 1$ for all $x, y \in X$ and $t > 0$. The 3-tuple $(X, \zeta_{M,N}, \Im)$ is said to be a *modified intuitionistic fuzzy metric space* if $X$ is an arbitrary non-empty set, $\Im$ is a continuous $t$-representable and $\zeta_{M,N}$ is a mapping from $X^2 \times (0, \infty)$ to $L^*$ satisfying the following conditions: for all $x, y, z \in X$ and $t, s > 0$,

(i) $\zeta_{M,N}(x, y, t) >_{L^*} 0_{L^*}$;

(ii) $\zeta_{M,N}(x, y, t) = 1_{L^*}$ if and only if $x = y$;
(iii) $\zeta_{M,N}(x, y, t) = \zeta_{M,N}(y, x, t)$;
(iv) $\zeta_{M,N}(x, y, t + s) \geq_{L^*} \Im(\zeta_{M,N}(x, z, t), \zeta_{M,N}(z, y, s))$;
(v) $\zeta_{M,N}(x, y, .) : (0, \infty) \to L^*$ is continuous.

In this case, $\zeta_{M,N}$ is called a *modified intuitionistic fuzzy metric*. Here, $\zeta_{M,N}(x, y, t) = (M(x, y, t), N(x, y, t))$ for all $x, y \in X$ and $t > 0$.

**Remark 2.4.** ([10]) In a modified intuitionistic fuzzy metric space $(X, \zeta_{M,N}, \Im)$, for any $t > 0$, $\zeta_{M,N}(x, y, t)$ is non-decreasing with respect to $t$ in $(L^*, \leq_{L^*})$ for all $x, y \in X$.

**Definition 2.5.** ([12]) Let $f$ and $g$ be self-mappings of a modified intuitionistic fuzzy metric space $(X, \zeta_{M,N}, \Im)$. Then the pair $(f, g)$ is said to be *commuting* if

$$\zeta_{M,N}(fgx, gfx, t) = 1_{L^*}$$

for all $x \in X$ and $t > 0$.

**Definition 2.6.** ([12]) Let $f$ and $g$ be self-mappings of a modified intuitionistic fuzzy metric space $(X, \zeta_{M,N}, \Im)$. Then the pair $(f, g)$ is said to be *weakly commuting* if

$$\zeta_{M,N}(fgx, gfx, t) \geq_{L^*} \zeta_{M,N}(fx, gx, t)$$

for all $x \in X$ and $t > 0$.

**Definition 2.7.** ([11], [12]) Let $f$ and $g$ be self-mappings of a modified intuitionistic fuzzy metric space $(X, \zeta_{M,N}, \Im)$. Then the pair $(f, g)$ is said to be *compatible* if

$$\lim_{n\to\infty} \zeta_{M,N}(fgx_n, gfx_n, t) = 1_{L^*}$$

for all $t > 0$, whenever $\{x_n\}$ is a sequence in $X$ such that $\lim_{n\to\infty} fx_n = \lim_{n\to\infty} gx_n = u$ for some $u \in X$.

**Definition 2.8.** ([11], [12]) Let $f$ and $g$ be self-mappings of a modified intuitionistic fuzzy metric space $(X, \zeta_{M,N}, \Im)$. Then the pair $(f, g)$ is is said to be *weakly compatible* if they commute at the coincidence points, that is, if $fu = gu$ for some $u \in X$, then $fgu = gfu$.

It is easy to see that compatible mappings are weakly compatible but converse is not true.

**Definition 2.9.** ([3], [7]) Let $f$ and $g$ be self-mappings of a modified intuitionistic fuzzy metric space $(X, \zeta_{M,N}, \Im)$. Then the pair $(f, g)$ is said to be *occasionally weakly compatible* if there exists a point $x \in X$ which is coincidence point of $f$ and $g$ at which $f$ and $g$ commute.

## 3. Main Results

Now, we prove common fixed point theorems for three mappings.

**Theorem 3.1.** *Let $(X, \zeta_{M,N}, \Im)$ be a modified intuitionistic fuzzy metric space. Suppose that $f, g$ and $h$ are three self-mappings on $X$ satisfying the following conditions:*

$$(C1) \qquad \int_0^{\zeta_{M,N}(fx,gy,t)} \phi(t)dt \leq_{L^*} \int_0^{P1} \phi(t)dt$$

*for all $x, y \in X$ and $\alpha, \beta, \gamma$ are non-negative reals numbers with $\alpha+2\beta+2\gamma < 1$, where*

$$\begin{aligned} P1 = {}& \alpha\zeta_{M,N}(hx, hy, t) + \beta[\zeta_{M,N}(fx, hx, t) + \zeta_{M,N}(gy, hy, t)] \\ & + \gamma[\zeta_{M,N}(hx, gy, t) + \zeta_{M,N}(hy, fx, t)] \end{aligned}$$

*and $\phi : \mathbb{R}^+ \to \mathbb{R}$ is a Lebesgue-integrable mapping which is summable, nonnegative and $\int_0^\epsilon \phi(t)dt > 0$ for each $\epsilon > 0$.*

*Assume that the pair $(f, h)$ or $(g, h)$ is occasionally weakly compatible.*

*Then $f, g$ and $h$ have a unique common fixed point.*

*Proof.* Suppose that the pair $(f, h)$ is occasionally weakly compatible. Then there exists an element $u \in X$ such that $fu = hu$ and $fhu = hfu$.

Now, we prove that $fu = gu$. Indeed, by inequality $(C1)$, we get

$$\begin{aligned} \int_0^{\zeta_{M,N}(fu,gu,t)} \phi(t)dt &\leq_{L^*} \int_0^{P2} \phi(t)dt \\ &= \int_0^{\beta\zeta_{M,N}(gu,fu,t)+\gamma\zeta_{M,N}(fu,gu,t)} \phi(t)dt \\ &<_{L^*} \int_0^{\zeta_{M,N}(fu,gu,t)} \phi(t)dt, \end{aligned}$$

where

$$\begin{aligned} P2 = {}& \alpha\zeta_{M,N}(hu, hu, t) + \beta[\zeta_{M,N}(fu, hu, t) + \zeta_{M,N}(gu, hu, t)] \\ & + \gamma[\zeta_{M,N}(hu, gu, t) + \zeta_{M,N}(hu, fu, t)], \end{aligned}$$

which is a contradiction and hence $gu = fu = hu$.

Again, suppose that $ffu \neq fu$. Then by $(C1)$, we have

$$\begin{aligned}\int_0^{\zeta_{M,N}(ffu,gu,t)} \phi(t)dt &\leq_{L^*} \int_0^{P3} \phi(t)dt \\ &= \int_0^{\alpha\zeta_{M,N}(ffu,gu,t)+2\gamma\zeta_{M,N}(ffu,gu,t)} \phi(t)dt \\ &<_{L^*} \int_0^{\zeta_{M,N}(ffu,gu,t)} \phi(t)dt,\end{aligned}$$

where

$$\begin{aligned}P3 = &\alpha\zeta_{M,N}(hfu,hu,t) + \beta[\zeta_{M,N}(ffu,hfu,t) + \zeta_{M,N}(gu,hu,t)] \\ &+ \gamma[\zeta_{M,N}(hfu,gu,t) + \zeta_{M,N}(hu,ffu,t)],\end{aligned}$$

which is a contradiction and hence $ffu = fu = hfu$.

Now, suppose that $gfu \neq fu$. Then by $(C1)$, we have

$$\begin{aligned}\int_0^{\zeta_{M,N}(fu,gfu,t)} \phi(t)dt &\leq_{L^*} \int_0^{P4} \phi(t)dt \\ &= \int_0^{\beta\zeta_{M,N}(gfu,fu,t)+\gamma\zeta_{M,N}(fu,gfu,t)} \phi(t)dt \\ &<_{L^*} \int_0^{\zeta_{M,N}(fu,gfu,t)} \phi(t)dt,\end{aligned}$$

where

$$\begin{aligned}P4 = &\alpha\zeta_{M,N}(hu,hfu,t) + \beta[\zeta_{M,N}(fu,hu,t) + \zeta_{M,N}(gfu,hfu,t)] \\ &+ \gamma[\zeta_{M,N}(hu,gfu,t) + \zeta_{M,N}(hfu,fu,t)],\end{aligned}$$

which is a contradiction and hence $gfu = fu$. Put $fu = gu = hu = z$. Therefore, $z$ is a common fixed point of $f, g$ and $h$.

Similarly, if the pair $(g, h)$ is occasionally weakly compatible, then $f, g$ and $h$ have a common fixed point.

Finally, let $z$ and $w$ $(z \neq w)$ be two common fixed points of $f, g$ and $h$.

Then from $(C1)$, we have

$$\begin{aligned}\int_0^{\zeta_{M,N}(z,w,t)} \phi(t)dt &= \int_0^{\zeta_{M,N}(fz,gw,t)} \phi(t)dt \\ &\leq_{L^*} \int_0^{P5} \phi(t)dt \\ &= \int_0^{\alpha\zeta_{M,N}(z,w,t)+2\gamma\zeta_{M,N}(z,w,t)} \phi(t)dt \\ &<_{L^*} \int_0^{\zeta_{M,N}(z,w,t)} \phi(t)dt,\end{aligned}$$

where

$$\begin{aligned}P5 = {}&\alpha\zeta_{M,N}(hz,hw,t) + \beta[\zeta_{M,N}(fz,hz,t) + \zeta_{M,N}(gw,hw,t)] \\ &+ \gamma[\zeta_{M,N}(hz,gw,t) + \zeta_{M,N}(hw,fz,t)],\end{aligned}$$

which is a contradiction and hence $z = w$. Thus the common fixed point is unique. This completes the proof. □

If we put $\phi(t) = 1$ in Theorem 3.1, we get the following corollary:

**Corollary 3.2.** *Let $(X, \zeta_{M,N}, \Im)$ be a modified intuitionistic fuzzy metric space. Suppose that $f, g$ and $h$ are three self-mappings on $X$ satisfying the following conditions:*

$$\begin{aligned}&\zeta_{M,N}(fx,gy,t) \\ &\leq_{L^*} \alpha\zeta_{M,N}(hx,hy,t) + \beta[\zeta_{M,N}(fx,hx,t) + \zeta_{M,N}(gy,hy,t)] \\ &\qquad + \gamma[\zeta_{M,N}(hx,gy,t) + \zeta_{M,N}(hy,fx,t)]\end{aligned}$$

*for all $x, y \in X$ and $\alpha, \beta, \gamma$ are non-negative reals numbers with $\alpha+2\beta+2\gamma < 1$.*

*Assume that the pair $(f, h)$ or $(g, h)$ is occasionally weakly compatible.*

*Then $f, g$ and $h$ have a unique common fixed point.*

Next, we prove common fixed point theorems for four mappings.

**Theorem 3.3.** *Let $(X, \zeta_{M,N}, \Im)$ be a modified intuitionistic fuzzy metric space. Suppose that $f, g, h$ and $k$ are four self-mappings on $X$ satisfying the following conditions:*

$$(C2) \qquad \int_0^{\zeta_{M,N}(fx,gy,t)} \phi(t)dt \leq_{L^*} \int_0^{Q1} \phi(t)dt$$

*for all* $x, y \in X$ *and* $\alpha, \beta, \gamma$ *are non-negative reals numbers with* $\alpha+2\beta+2\gamma < 1$, *where*

$$\begin{aligned} Q1 = {} & \alpha\zeta_{M,N}(hx, ky, t) + \beta[\zeta_{M,N}(fx, hx, t) + \zeta_{M,N}(gy, ky, t)] \\ & + \gamma[\zeta_{M,N}(hx, gy, t) + \zeta_{M,N}(ky, fx, t)] \end{aligned}$$

*and* $\phi : \mathbb{R}^+ \to \mathbb{R}$ *is a Lebesgue-integrable mapping which is summable, nonnegative and* $\int_0^\epsilon \phi(t)dt > 0$ *for each* $\epsilon > 0$.

*Assume that the pairs* $(f, h)$ *and* $(g, k)$ *are occasionally weakly compatible. Then* $f, g, h$ *and* $k$ *have a unique common fixed point.*

*Proof.* Since pairs of mappings $(f, h)$ and $(g, k)$ are occasionally weakly compatible. Then there exists two points $u, v \in X$ such that $fu = hu$ and $fhu = hfu$, $gv = kv$ and $gkv = kgv$.

Now, we prove that $fu = gv$. Indeed, by $(C2)$, we get

$$\begin{aligned} \int_0^{\zeta_{M,N}(fu,gv,t)} \phi(t)dt &\leq_{L^*} \int_0^{Q2} \phi(t)dt \\ &= \int_0^{\alpha\zeta_{M,N}(fu,gv,t)+2\gamma\zeta_{M,N}(fu,gv,t)} \phi(t)dt \\ &<_{L^*} \int_0^{\zeta_{M,N}(fu,gv,t)} \phi(t)dt, \end{aligned}$$

where

$$\begin{aligned} Q2 = {} & \alpha\zeta_{M,N}(hu, kv, t) + \beta[\zeta_{M,N}(fu, hu, t) + \zeta_{M,N}(gv, kv, t)] \\ & + \gamma[\zeta_{M,N}(hu, gv, t) + \zeta_{M,N}(kv, fu, t)], \end{aligned}$$

which is a contradiction and hence $gv = fu = hu = kv$.

Again, suppose that $ffu = fhu = hfu \neq fu$. Then by $(C2)$, we have

$$\begin{aligned} \int_0^{\zeta_{M,N}(ffu,gv,t)} \phi(t)dt &\leq_{L^*} \int_0^{Q3} \phi(t)dt \\ &= \int_0^{\alpha\zeta_{M,N}(ffu,gv,t)+2\gamma\zeta_{M,N}(ffu,gv,t)} \phi(t)dt \\ &<_{L^*} \int_0^{\zeta_{M,N}(ffu,gv,t)} \phi(t)dt, \end{aligned}$$

where

$$\begin{aligned} Q3 = {} & \alpha\zeta_{M,N}(hfu, kv, t) + \beta[\zeta_{M,N}(ffu, hfu, t) + \zeta_{M,N}(gv, kv, t)] \\ & + \gamma[\zeta_{M,N}(hfu, gv, t) + \zeta_{M,N}(kv, ffu, t)], \end{aligned}$$

which is a contradiction and hence $ffu = fu = hfu = fhu$.

Similarly, we obtain $gfu = kfu = fu$. Put $fu = z$. Therefore, $z$ is a common fixed point of $f, g, h$ and $k$.

Finally, let $z$ and $w$ $(z \neq w)$ be two common fixed points of $f, g, h$ and $k$. Then from $(C2)$, we have

$$\begin{aligned}\int_0^{\zeta_{M,N}(z,w,t)} \phi(t)dt &= \int_0^{\zeta_{M,N}(fz,gw,t)} \phi(t)dt \\ &\leq_{L^*} \int_0^{Q4} \phi(t)dt \\ &= \int_0^{\alpha\zeta_{M,N}(z,w,t)+2\gamma\zeta_{M,N}(z,w,t)} \phi(t)dt \\ &<_{L^*} \int_0^{\zeta_{M,N}(z,w,t)} \phi(t)dt,\end{aligned}$$

where

$$\begin{aligned}Q4 = \alpha\zeta_{M,N}(hz, kw, t) &+ \beta[\zeta_{M,N}(fz, hz, t) + \zeta_{M,N}(gw, kw, t)] \\ &+ \gamma[\zeta_{M,N}(hz, gw, t) + \zeta_{M,N}(kw, fz, t)],\end{aligned}$$

which is a contradiction and hence $z = w$. Thus, the common fixed point is unique. This completes the proof. □

If we put $\phi(t) = 1$ in Theorem 3.3, we get the following corollary:

**Corollary 3.4.** *Let $(X, \zeta_{M,N}, \Im)$ be a modified intuitionistic fuzzy metric space. Suppose that $f, g, h$ and $k$ are four self-mappings on $X$ satisfying the following conditions:*

$$\begin{aligned}&\zeta_{M,N}(fx, gy, t) \\ &\leq_{L^*} \alpha\zeta_{M,N}(hx, ky, t) + \beta[\zeta_{M,N}(fx, hx, t) + \zeta_{M,N}(gy, ky, t)] \\ &\quad + \gamma[\zeta_{M,N}(hx, gy, t) + \zeta_{M,N}(ky, fx, t)]\end{aligned}$$

*for all $x, y \in X$ and $\alpha, \beta, \gamma$ are non-negative reals numbers with $\alpha+2\beta+2\gamma < 1$.*

*Assume that the pairs $(f, h)$ and $(g, k)$ are occasionally weakly compatible. Then $f, g, h$ and $k$ have a unique common fixed point.*

**Example 3.5.** Let $X = [0, \infty)$ with the modified intuitionistic fuzzy metric

$$\zeta_{M,N}(x, y, t) = \left(\frac{t}{t + |x - y|}, \frac{|x - y|}{t + |x - y|}\right)$$

for all $t > 0$ and $x, y \in X$. Define

$$fx = gx = \begin{cases} 0, & x \in [0,1), \\ 1, & x \in [1,\infty), \end{cases}$$

$$hx = \begin{cases} 3, & x \in [0,1), \\ \frac{1}{x}, & x \in [1,\infty), \end{cases} \qquad kx = \begin{cases} 9, & x \in [0,1), \\ \frac{1}{\sqrt{x}}, & x \in [1,\infty). \end{cases}$$

Clearly the pairs $(f,h)$ and $(g,k)$ are occasionally weakly compatible. Also if we define $\phi(x) = 3x^2$ and by taking $\alpha = \frac{1}{4}$, $\beta = \frac{1}{5}$ and $\gamma = \frac{1}{6}$, then all the hypotheses of Theorem 3.3 are satisfied and $x = 1$ is a unique common fixed point of $f, g, h$ and $k$.

## References

[1] C. Alaca, D. Türkoğlu, C. Yildiz, Fixed points in intuitionistic fuzzy metric spaces, *Chaos Solitons Fractals*, **29**, No. 5 (2006), 1073-1078, **doi:** 10.1016/j.chaos.2005.08.066

[2] K.T. Atanassov, Intuitionistic fuzzy sets, *Fuzzy Sets and Systems*, **20**, No. 1 (1986), 87-96, **doi:** 10.1016/S0165-0114(86)80034-3

[3] H. Chandra, A. Bhatt, Fixed point theorems for occasionally weakly compatible maps in probabilistic semi-metric space, *Int. J. Math. Anal.*, **3**, No. 12 (2009), 563-570.

[4] G. Deschrijver, C. Cornelis, E.E. Kerre, On the representation of intuitionistic fuzzy $t$-norm and $t$-conorms, *IEEE Trans. Fuzzy System*, **12**, No. 1 (2004), 45-61, **doi:** 10.1109/TFUZZ.2003.822678

[5] V. Gregori, S. Romaguera, P. Veeramani, A note on intuitionistic fuzzy metric spaces, *Chaos Solitons Fractals*, **28**, No. 4 (2006), 902-905, **doi:** 10.1016/j.chaos.2005.08.113

[6] G. Jungck, Commuting mappings and fixed points, *Amer. Math. Monthly*, **83**, No. 4 (1976), 261-263, **doi:** 10.2307/2318216

[7] G. Jungck, B.E. Rhoades, Fixed point theorems for occasionally weakly compatible mappings, *Fixed Point Theory*, **7**, No. 2 (2006), 286-296.

[8] I. Kramosil, J. Michálek, Fuzzy metric and statistical metric spaces, *Kybernetika*, **11**, No. 5 (1975), 336-344.

[9] J.H. Park, Intuitionistic fuzzy metric spaces, *Chaos Solitons Fractals*, **22**, No. 5 (2004), 1039-1046, **doi:** 10.1016/j.chaos.2004.02.051

[10] R. Saadati, J.H. Park, On the intuitionistic topological spaces, *Chaos Solitons Fractals*, **27**, No. 2 (2006), 331-344, **doi:** 10.1016/j.chaos.2005.03.019

[11] R. Saadati, S. Sedghi, N. Shobhe, Modified intuitionistic fuzzy metric spaces and some fixed point theorems, *Chaos Solitons Fractals*, **38**, No. 1 (2008), 36-47, **doi:** 10.1016/j.chaos.2006.11.008

[12] M. Tanveer, M. Imdad, D. Gopal, D. Kumar, Common fixed point theorems in modified intuitionistic fuzzy metric spaces with common property (E.A), *Fixed Point Theory Appl.*, **2012**, No. 36 (2012), 12 pages, **doi:** 10.1186/1687-1812-2012-36

[13] D. Türkoğlu, C. Alaca, Y.J. Cho, C. Yildiz, Common fixed point theorems in intuitionistic fuzzy metric spaces, *J. Appl. Math Comput.*, **22**, No. 1-2 (2006), 411-424, **doi:** 10.1007/BF02896489.