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Polish Botanical Journal 59(2): 235–247, 2014
DOI: 10.2478/pbj-2014-0039

NEW RECORDS OF *PHACUS* AND *MONOMORPHINA* TAXA (EUGLENOPHYTA) FOR THAILAND

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Abstract. The diversity of *Phacus* and *Monomorphina* (Euglenophyta) from northern Thailand was studied in various water bodies of Chiang Mai, Chiang Rai, Lamphun, Lampang and Phayao provinces. This paper presents 25 taxa of *Phacus* and 1 *Monomorphina* new for Thailand, including 3 *Phacus* taxa new for Southeast Asia. Several varieties and forms were recognized. All are briefly described, with original illustrations.

Key words: biodiversity, Euglenophyta, *Monomorphina*, new record, *Phacus*, Thailand

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Introduction

Among the twelve genera of photosynthetic euglenophytes the most frequently reported ones are *Phacus* Dujard. and *Monomorphina* Mereschk. *emend*. Kosmala & Zakryś. The cells of this group are rigid, oval, spherical, clavate or pear-shaped, flattened and usually leaf-shaped. According to Starmach (1983) and Wołowski (1998, 2011) they occur mainly in ponds, marshes, weedy waters, rivers and bogs, together with other species of euglenoids. Like other euglenoids they are considered to be saprobes (e.g., Sladeček & Sladečkova 1996), most of which are classified as β-α mesosaprobes. Regardless of the water assessment system, a large number of euglenoids are always associated with organic pollution.

Information about Euglenophya taxa in Thailand is still scarce. As in many others countries, the main sources of information about euglenoids are references in studies investigating various taxonomic groups of algae; the majority of these works contain neither iconographic nor descriptive documentation (Wołowski 1998). This applies to all the hydrobiological and floristic studies of Thailand known to us. Data on 14 euglenophyte taxa occurring in central Thailand are included in a study of phytoplankton from Lake Boraphet (Hirano 1975). Pongswat *et al*. (2004) and Hanpongkittikul and Wongrat (2005) also give some data on euglenophytes from this part of Thailand. Some hydrobiological studies of water bodies in southern Thailand mention single taxa (4) from the Banglang Reserve (Ariyadej *et al*. 2004). In a study of freshwater protozoa of Chonburi Province in eastern Thailand, Matchacheep and Dumrongrojwattana (2004) reported 24 euglenophyte taxa: 6 taxa of *Phacus*, 11 *Euglena* and 7 *Trachelomonas*. Ngearnpat (2003) and Panuvanitchakorn (2003) gave a few data on euglenoids occurring in various water bodies of northeastern Thailand. Very useful data can be found in work reporting the biodiversity of freshwater protozoa in Thailand (Charubhun & Charubhun 2000), including data on 44 euglenophytes, including 6 colorless taxa and 12 *Phacus*, 16 *Euglena*, 6 *Trachelomonas*, 2 *Strombomonas*, 1 *Lepocinclis* and 1 *Cryptoglena*.

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The main sources of information about the group are references given by Lewmanomont *et al*. (1995) and Pongswat *et al*. (2004) in publications on different algal taxonomic groups. In the most detailed monograph on euglenophytes from Thailand, Yamagishi (2010) gave data for 5 taxa of *Lepocinclis*, 18 *Phacus*, 31 *Trachelomonas* and 7 *Strombomonas* occurring in ponds and lakes of central and southern Thailand. All of them are described and have good documentation. Chaimongkhon and Peerapornpisal (2012) recognized several taxa from ditches around a rice paddy in Saraphi District, Chiang Mai. Peerapornpisal (2013) documented 12 *Phacus* taxa from freshwaters without information about the site of occurrence. That work also notes 12 taxa of *Euglena*, 5 *Lepocinclis*, 6 *Strombomonas*, 12 *Trachelomonas* and 26 colorless taxa. Duangjan *et al*. (2012) described, with LM and SEM documentation, 49 *Trachelomonas* taxa reported from northern Thailand. Duangjan and Wołowski (2013) made a detailed study of new taxa of *Strombomonas* and *Trachelomonas*.

This paper reports the results of a study on *Phacus* and *Monomorphina* from various small water bodies in the northern part of Thailand, a country in which tropical wet and dry climate prevails in most areas.

Material and methods

Samples were taken from April 2009 to March 2010 in Chiang Mai, Chiang Rai, Lamphun, Lampang and Phayao provinces (Fig. 1a). All the sites where *Phacus* and *Monomorphina* occurred are listed in Table 1.

Representatives of *Phacus* and *Monomorphina* were found in highly polluted water bodies. The water pH ranged from 5.0 to 9.4, conductivity from 74 to 1104 µS/cm, and nutrient levels of n.d.–2.37 mg/L nitrate nitrogen, n.d.–5.62 mg/L ammonium nitrogen and n.d.–1.45 mg/L orthophosphates.

Samples were collected with a plankton net (10 µm pore size) into a plastic flask (*ca* 100 ml) and divided into two parts. One part was preserved with Lugol's solution and studied by SEM, and the other part was transported as fresh material and studied by LM in the laboratory. All descriptions are based on phenotype observations of living specimens by LM.

The physicochemical properties of water such as pH, conductivity and nutrients (nitrate nitrogen, ammonium nitrogen, orthophosphate) were analyzed. Water pH and conductivity were determined with an SMS125 pH/ORP controller. Nutrient concentrations (PO_4, NO_3, NH_4) were measured in the laboratory: nitrate nitrogen analysis by the cadmium reduction method, ammonium nitrogen analysis by the Nesslerization method, orthophosphate by the ascorbic acid method (Greenberg *et al.* 2005).

Nomenclature data were elaborated according to Starmach (1983), Pochmann (1942), Huber-Pestalozzi (1955), Wołowski (1998), Wołowski and Hindák (2005), Wołowski (2011), Marin *et al*. (2003), Kim *et al*. (2013) and Ciugulea and Triemer (2010).

Results and discussion

Here we report 25 *Phacus* taxa and one *Monomorphina* species as new for the Thai flora of algae. Species new to Southeast Asia are asterisked (*). All descriptions are based on observations of morphological characters. Both genera occurred in high-nutrient water, especially in ponds, swamps and ditches, and frequently they occurred together.

Monomorphina pseudopyrum Kosmala, Milanowski, Brzóska, Pękala, Kwiatowski & Zakryś 2007 Figs 2a & 3a

Cells 26–37 µm long and 10–16 µm wide, spindle-shaped, pear-shaped; one orbicular perforated chloroplast; two lateral paramylon bodies; pellicle obliquely ribbed; nucleus usually in posterior part.

Sites: Chiang Mai – garden ponds (AG, PK), fish ponds (UM, MJ1), Lampang – fish pond (KL); Lamphun – ditches (LL, LP2), field ponds (LP1, BL); Chiang Rai – fish pond (CC1), garden pond (BY1, BY2); Phayao – fish pond (PS1).

General occurrence. Probably cosmopolitan.

Phacus acuminatus Stokes var. ***acuticauda*** (Roll) Pochmann 1942 Figs 2b & 3b

Cells 30.0–37.5 µm long and 22–30 µm wide, broadly triangular, incised anterior end, shallow

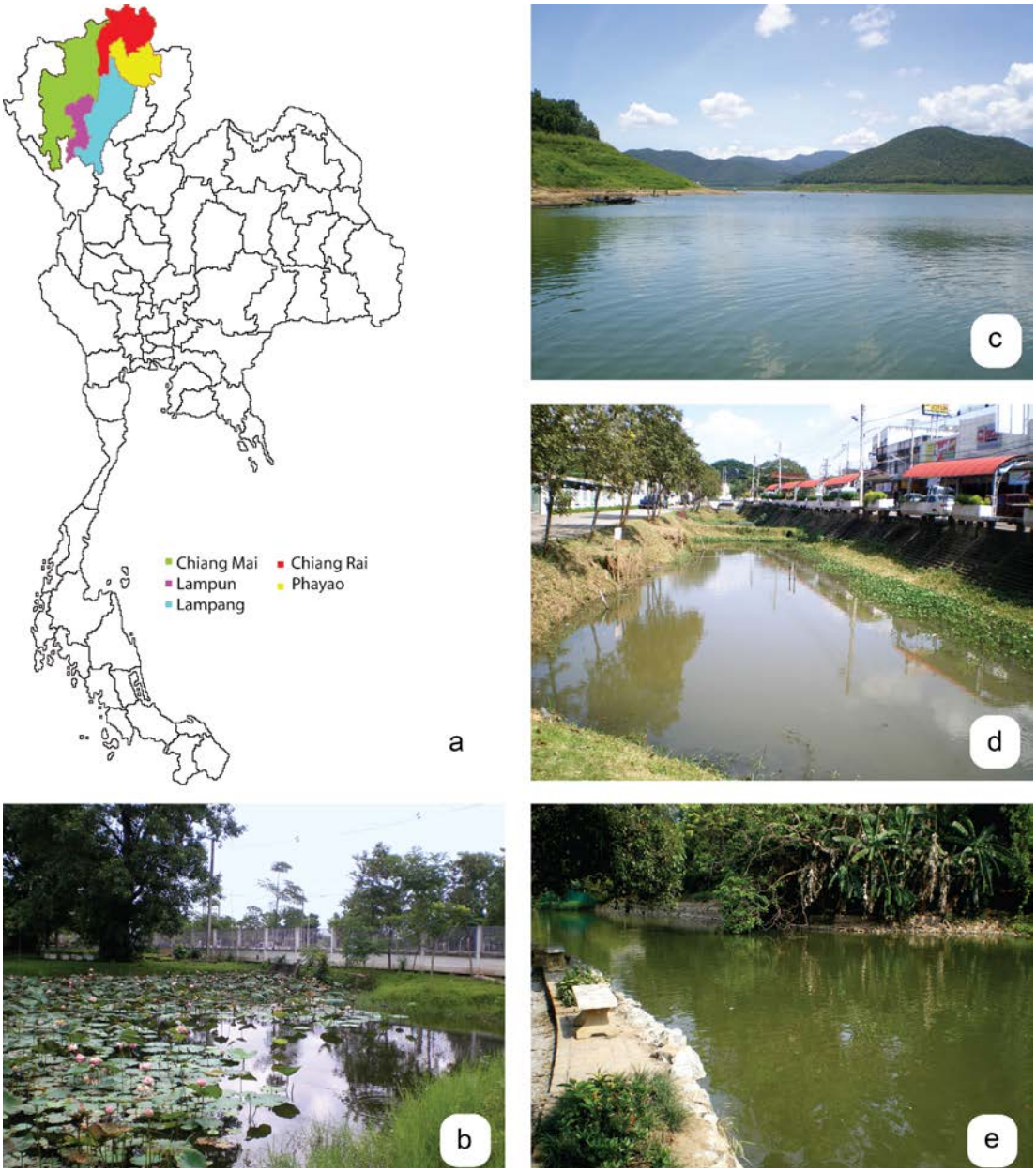

Fig. 1. Study area in northern Thailand (a) and sampling sites (b – garden pond at Chiang Mai University, c – dam built across the Mae Kuang River, d – ditch in front of Phayao Kindergarten, e – fish pond at Wat Umong).

dorsal groove extending half to three quarters of cell length; distinctly conical cauda; two unequal, ring-shaped paramylon bodies.

Note. The variety is barely distinguishable from the nominative variety, from which it differs by having cells triangular in outline.

Sites: Chiang Mai – dam on Mae Kuang River (MK); Lampang – fish pond (TJ).

Table 1. Sampling sites. * = samples collected every month over a single year from April 2009 to March 2010

Province	Site code	Geographical coordinates	Site characteristics
1. Chiang Mai	AG	18°47′36.00″N 98°57′40.02″E	*Garden pond at Chiang Mai University, shallow, transparent, with *Lotus* spp.
	UM	18°46′55.98″N 98°57′05.46″E	*Fish pond at Wat Umong, mostly with catfish
	MJ1	18°53′55.80″N 99°00′59.94″E	*Fish pond at Maejo University, with Mekong giant catfish
	MK	18°56′36.1″N 99°08′5.90″E	Dam built across the Mae Kuang River
	PK	18°47′36.48″N 98°57′54.72″E	Garden pond in the park near Chiang Mai University Hall
	MJ2	18°53′54.90″N 99°0′59.88″ E	Fish pond at Maejo University, with Mekong giant catfish
	MJ3	18°53′55.38″N 99°01′02.94″E	Fish pond at Maejo University, with Mekong giant catfish
	MJ4	18°53′56.28″N 99°00′57.90″E	Fish pond at Maejo University, with Mekong giant catfish
2. Lampang	KL	18°19′8.22″N 99°28′0.54″E	*Fish pond at Khelang Nakorn School, with Nile tilapia
	TJ	18°18′37.80″N 99°29′41.94″E	*Fish pond at Wat Phra Jao Tanjai, with Nile tilapia, with water hyacinth
	RF	18°18′54.12″N 99°26′22.50″E	Rice paddy at road side
3. Lamphun	LL	18°32′44.04″N 99°01′57.60″E	Ditch in front of Lanlao restaurant
	BL	18°36′41.70″N 99°02′03.18″E	Field pond in front of Bualuang restaurant
	LP1	18°38′07.62″N 99°03′03.42″E	Field pond near agriculture areas, at road side
	LP2	18°38′06.66″N 99°03′02.58″E	Ditch near agriculture areas
4. Chiang Rai	CC1	19°16′02.46″N 99°30′42.60″E	Fish pond in the area of Cabbage & Condom Inn and Restaurant, with a carp
	BY1	19°47′07.20″N 99°44′40.38″E	Garden pond at the Pa Ko Dam Tobacco station, shallow 4.3 Hui Yah Khamma Reservoir
	WM	19°10′57.30″N 99°29′41.46″E	Reservoir for the preservation of freshwater fish
	CC2	19°16′02.46″N 99°30′42.60″E	Ditch in the area of Cabbage & Condom Inn and Restaurant
	BY2	19°47′5.52″N 99°44′39.24″E	Garden pond at the Pa Ko Dam Tobacco station, shallow, with ducks
5. Phayao	AS	19°10′17.16″N 99°54′04.38″E	*Ditch in front of Phayao School Kindergarten
	PS1	19°10′16.80″N 99°54′35.82″E	*Fish pond at Phayaopitthayakom School, with fishpens
	PS2	19°10′14.70″N 99°54′35.82″E	Garden pond in area of Phayaopitthayakom School

General occurrence. Not common.

Phacus acuminatus var. ***indica*** (Pochmann) Huber-Pestalozzi 1955 Figs 2c & 3c

Cells 22 µm long and 17.5–20.0 µm wide, broadly rectangular, incised anterior end, shallow dorsal groove extending half to three quarters of cell length; short cauda; two disc-shaped paramylon bodies.

Note. The variety is barely distinguishable from the nominative variety, from which it differs by having cells rectangular in outline.

Sites: Chiang Rai – fish pond (CC1), garden pond (BY1).

General occurrence. Rarely reported.

Phacus acuminatus var. ***javana*** (Pochmann) Huber-Pestalozzi Figs 2d & 3d

Cells 30.0–32.5 µm long and 25.0–27.5 µm wide, broadly ovoid, incised anterior end, shallow dorsal groove extending half to three quarters of cell length; short cauda; two ring-shaped paramylon bodies lying side by side.

Note. The variety is barely distinguishable from the nominative variety, from which it differs by having cells pentagonal in outline.

Sites: Chiang Mai – garden pond (AG), fish pond (MJ4); Lamphun – field pond (BL, LP1); Chiang Rai – fish pond (CC1); Phayao – fish pond (PS1).

General occurrence. Rarely reported.

Phacus alatus Klebs 1883 Figs 2e & 3e

Cells 42.5–45.0 µm long and 30–35 µm wide, broadly ovoid, posterior part with strong curved cauda; two large lateral paramylon bodies.

Sites: Chiang Mai – fish pond (UM), Lampang – fish pond (KL).

General occurrence. Worldwide, commonly reported.

Phacus anomalus var. ***pullus-gallinae*** Nygaard 1949 Figs 2f & 3f

Cells 22.0–28.6 µm long and 15–20 µm wide, ±elliptical in outline, 14–15 µm thick, two unequal parts, broad furrow on ventral side, 3–4 µm wide; two large paramylon bodies.

Note. The variety is barely distinguishable from the nominative variety, from which it differs by having a ventral furrow dividing the cell into two unequal parts.

Sites: Chiang Mai – garden pond (AG), fish ponds (UM, MJ1), dam at the Mae Kuang River (MK); Lampang – fish ponds (KL, TJ); Lamphun – ditch (LL), field ponds (BL, LP); Chiang Rai – fish pond – (CC1), garden ponds – (BY1, BY2), freshwater reservoir (WM); Phayao – ditch (AS), fish pond – (PS1).

General occurrence. Not common.

****Phacus asymmetricus*** Sokoloff 1933 Figs 2g & 3g

Cells 40–46 µm long and 28–38 µm wide, irregularly and strongly twisted, with several indentations; cauda curved; two large elliptical paramylon bodies.

Sites: Chiang Rai – fish pond (CC1).

General occurrence. Rarely reported.

Phacus caudatus var. ***tenuis*** Swirenko 1915 Figs 2h & 3h

Cells 28.0–37.5 µm long and 14.0–17.5 µm wide, ovoid, pear-shaped, often slightly twisted, ridge running full length of cell, triangular in cross-section; curved or sharply pointed 3–6 µm long cauda; 1–2 large ring-shaped paramylon bodies.

Sites: Chiang Mai – garden pond (AG) fish pond (UM), field ponds – (BL, LP1); Chiang Rai – fish pond (CC1) garden pond (BY1).

General occurrence. Worldwide, probably cosmopolitan.

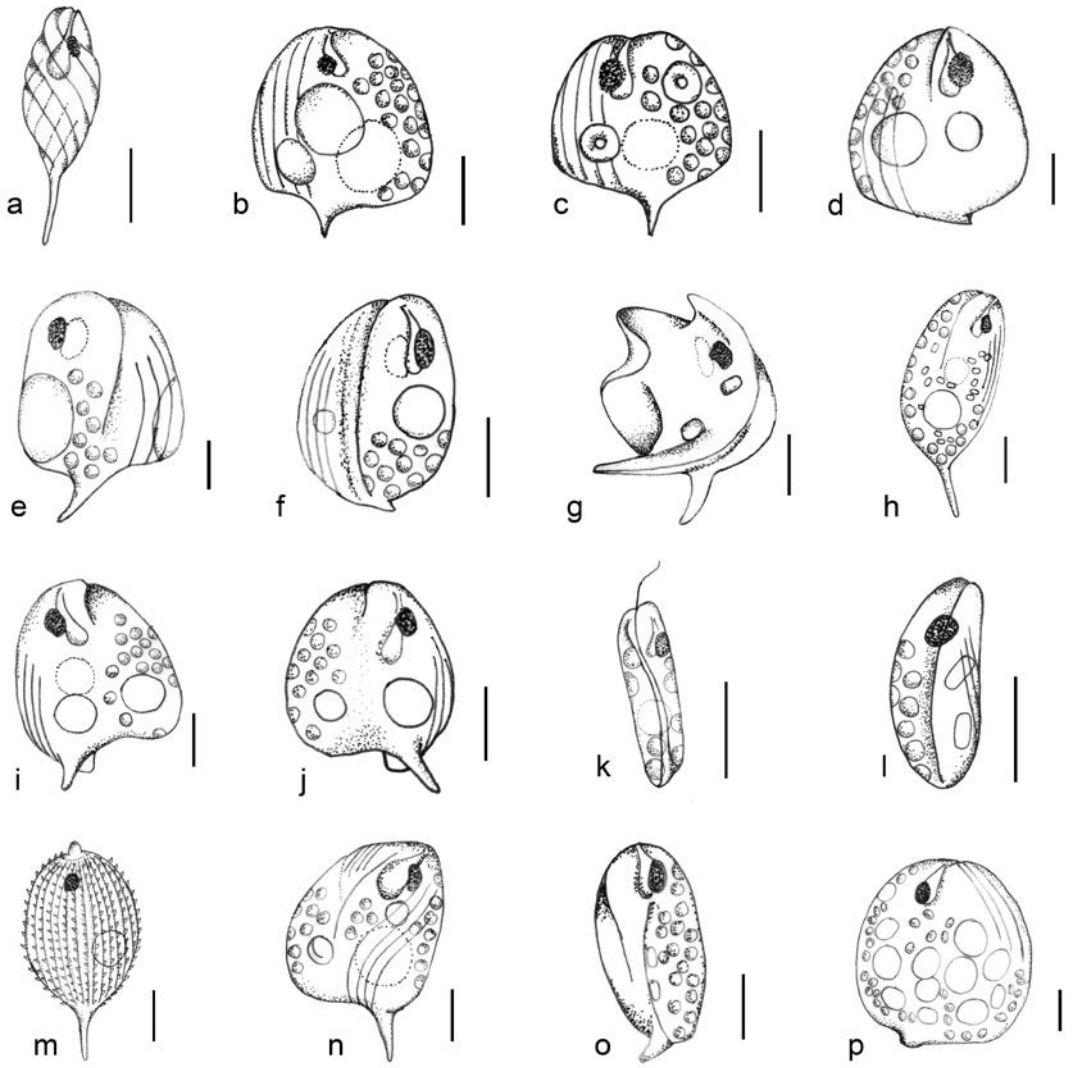

Fig. 2. a – *Monomorphina pseudopyrum* Kosmala, Milanowski, Brzoska, Pękala, Kwiatowski & Zakryś, b – *Phacus acuminatus* var. *acuticauda* (Roll) Pochmann, c – *Ph. acuminatus* var. *indica* (Pochmann) Huber-Pestalozzi, d – *Ph. acuminatus* var. *javana* (Pochmann) Huber-Pestalozzi, e – *Ph. alatus* Klebs, f – *Ph. anomalus* var. *pullus-gallinae* Nygaard, g – *Ph. asymmetricus* Prescott, h – *Ph. caudatus* var. *tenuis* Swirenko, i – *Ph. contortus* Bourrelly, j – *Ph. contortus* fo. *minor* Bourrelly, k – *Ph. cylindraceus* Popova, l – *Ph. dangeardii* Lemmermann, m – *Ph. hispidulus* (Eichwald) Lemmermann, n – *Ph. inflatus* var. *pterophora* Skuja, o – *Ph. inflexus* (I. Kisselev) Pochmann, p – *Ph. lefevrei* Bourrelly. Scale bars = 10 µm.

Phacus contortus Bourrelly 1952 Figs 2i & 3i

Cells 45–50 µm long and 30.0–37.5 µm wide, ovoid to triangular-ovoid, usually broadest and strongly twisted at posterior end, convex dorsally, concave ventrally, with 8–10 µm long, narrow, curved cauda; two circular paramylon bodies.

Sites: Chiang Mai – fish pond (UM), dam across Mae Kuang River (MK); Lampang – fish ponds (KL, TJ); Lamphun – ditch (LL), field pond (BL); Chiang Rai – fish pond (CC1), garden pond (BY1).

General occurrence. Common.

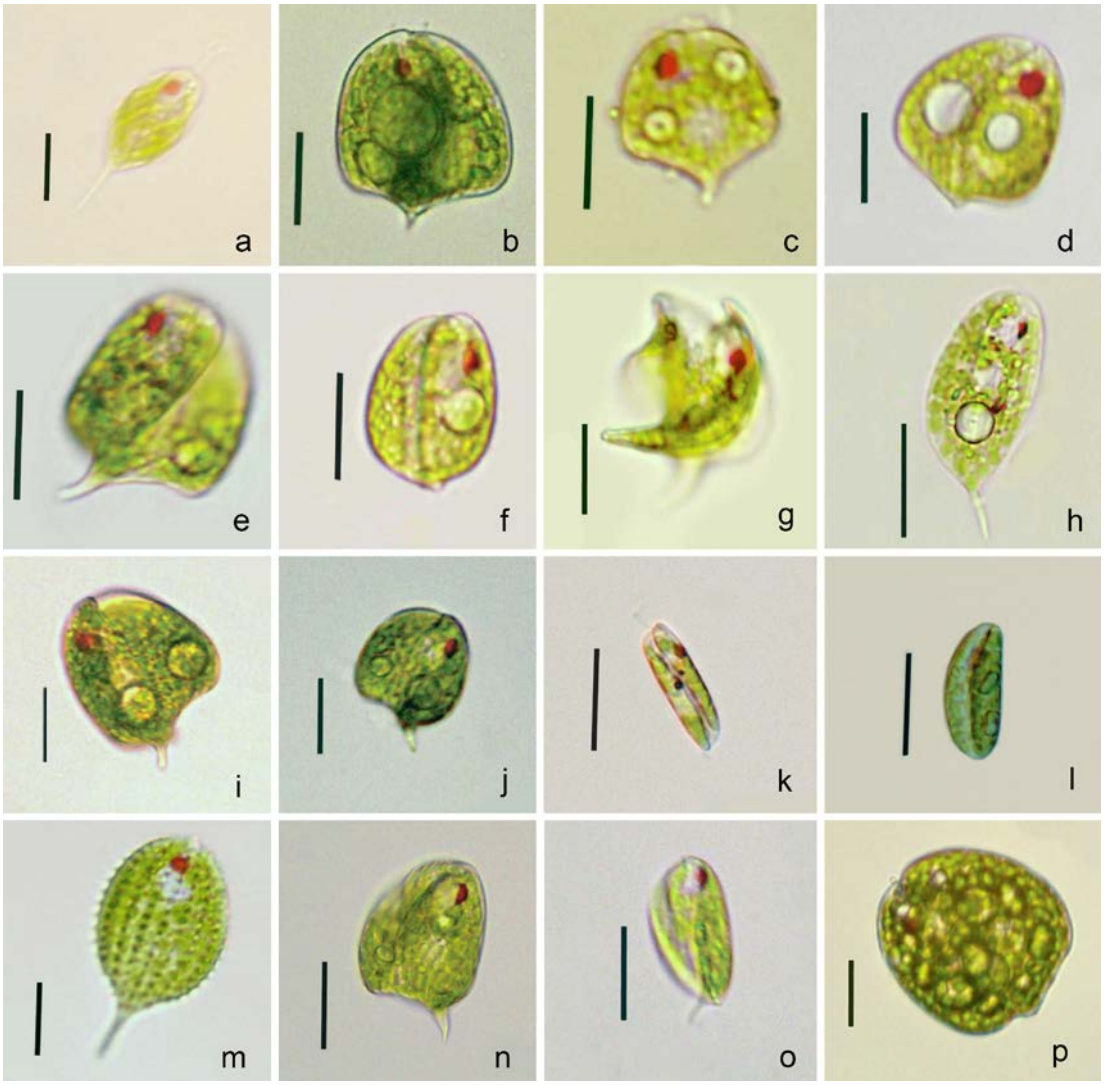

Fig. 3. a – *Monomorphina pseudopyrum* Kosmala, Milanowski, Brzoska, Pękala, Kwiatowski & Zakryś, b – *Phacus acuminatus* var. *acuticauda* (Roll) Pochmann, c – *Ph. acuminatus* var. *indica* (Pochmann) Huber-Pestalozzi, d – *Ph. acuminatus* var. *javana* (Pochmann) Huber-Pestalozzi, e – *Ph. alatus* Klebs, f – *Ph. anomalus* var. *pullus-gallinae* Nygaard, g – *Ph. asymmetricus* Prescott, h – *Ph. caudatus* var. *tenuis* Swirenko, i – *Ph. contortus* Bourrelly, j – *Ph. contortus* fo. *minor* Bourrelly, k – *Ph. cylindraceus* Popova, l – *Ph. dangeardii* Lemmermann, m – *Ph. hispidulus* (Eichwald) Lemmermann, n – *Ph. inflatus* var. *pterophora* Skuja, o – *Ph. inflexus* (I. Kisselev) Pochmann, p – *Ph. lefevrei* Bourrelly. Scale bars = 10 µm.

* ***Phacus contortus*** fo. ***minor*** Bourrelly 1961
Figs 2j & 3j

Cells 28–30 µm long and 18.7–25.0 µm wide, ovoid to triangular-ovoid, usually broadest at posterior end, concave ventrally; narrow, curved cauda 8–10 µm long; two circular paramylon bodies.

Note. It differs from the nominative form in the dimensions of the cell, which is smaller.

Sites: Chiang Mai – fish pond (UM); Lampang – fish pond (KL).

General occurrence. Rarely reported.

Phacus cylindraceus Popova 1955 Figs 2k & 3k

Cells (12.5–)19.0–20.0 µm long and 5.0–7.5 µm wide, long-cylindrical, obliquely truncate, shallowly bilobate, slightly narrowed at anterior and posterior ends, posterior end obtuse or pointed; two rod-shaped paramylon bodies, one large and one smaller.

Sites: Chiang Mai – fish pond (UM, MJ1), garden pond (PK); Lampang – fish pond (KL); Lamphun – ditch (LL), field ponds (BL, LP1); Chiang Rai – garden pond (BY1).

General occurrence. Probably common but rarely reported.

Phacus dangeardii Lemmermann 1910 Figs 2l & 3l

Cells 20.0–22.5 µm long and 7–8 µm wide, ovoid, distinct groove at apical; 1–2 ring-shaped paramylon bodies.

Sites: Chiang Mai – dam across Mae Kuang River (MK); Lampang – fish pond (KL); Lamphun – field pond (BL); Phayao – ditch (AS).

General occurrence. Not common.

Phacus hispidulus (Eichwald) Lemmermann 1910 Figs 2m & 3m

Cells 50 µm long and 25 µm wide, ovoid, median protuberance at anterior end; sharp or blunt cauda; pellicle longitudinal, with row of small spines directed to anterior; two large lateral and several smaller paramylon bodies.

Sites: Lampang – fish pond (KL).

General occurrence. Rarely reported.

Phacus inflatus var. ***pterophora*** Skuja 1949 Figs 2n & 3n

Cells 45–50 µm long and 28–30 µm wide, ovoid, 2 asymmetrical parts, 20–22 µm thick, slightly curved, shorter cauda than type form (type form 4–6 µm); large ring-shaped paramylon body.

Note. It differs from the nominative variety in the dimensions of the cell, which is bigger.

Sites: Chiang Mai – fish pond (UM); Lampang – fish pond (KL); Lamphun – field pond (BL); Chiang Rai – fish pond (CC1), garden ponds (BY1, BY2).

General occurrence. Rarely reported.

Phacus inflexus (I. Kisselev) Pochmann 1942 Figs 2o & 3o

Cells 17.5-25.0 µm long and 10–15 µm wide, strongly S-shaped, flattened, folded almost in two, incised at anterior end; short blunt cauda; 1–2 variously sized paramylon bodies.

Sites: Chiang Mai – fish pond (UM); Lampang – fish pond (KL); Lamphun – field pond (BL).

General occurrence. Not common.

Phacus lefevrei Bourrelly 1952 Figs 2p & 3p

Cells 45–50 µm long and 40.0–42.5 µm wide, broadly ovoid to suborbicular, shallowly bilobate, slightly narrowed at anterior end, apical groove almost the length of the cell; short round cauda; single circular or ring-shaped paramylon body.

Sites: Chiang Mai – garden pond (AG); Lampang – fish pond (KL).

General occurrence. Rarely reported.

Phacus longicauda var. ***attenuata*** (Pochmann) Huber-Pestalozzi 1955 Figs 4a & 5a

Cells 100–149 µm long and 37.5–50.0 µm wide, broadly obovoid, clavate in outline, bilobate at anterior end; gradually attenuating to a long thin cauda; usually a single ring-shaped or circular paramylon body.

Note. It differs from the nominative variety by having cells clavate in outline.

Sites: Chiang Mai – fish pond (UM); Lampang – fish ponds (KL, TJ); Chiang Rai – fish

pond (CC1), garden pond (BY1); Phayao – fish pond (PS1).

General occurrence. Probably common.

Phacus mangini var. ***inflata*** Nygaard 1949 Figs 4b & 5b

Cells 37.5–50.0 µm long and 25 µm wide, asymmetrical-ovoid to broadly ovoid, 10–14 µm thick low longitudinal groove at one side; cauda 14 µm long; two circular paramylon bodies.

Note. It differs from the nominative variety by having a slightly convex ventral side of the cell.

Sites: Lampang – fish ponds (KL, TJ); Lamphun – field pond (BL); Chiang Rai – fish pond (CC1).

General occurrence. Rarely reported.

Phacus morii Skvortzov 1928 Figs 4c & 5c

Cells 62–68 µm long and 33–35 µm wide, broadly obovoid, 6–7 deep grooves on edge, bilobate at anterior end; gradually attenuating to a long thin cauda; usually with single ring-shaped or circular plate paramylon body.

Sites: Chiang Mai – fish pond (UM), garden pond (PK); Lampang – fish pond (TJ); Lamphun – ditch (LL).

General occurrence. Not common, rarely reported.

Phacus parvulus Klebs 1883 Figs 4d & 5d

Cells 12.0–17.5 µm long and 5.0–8.0(–12.5) µm wide, obovoid to ovoid or heart-shaped, rounded and obliquely truncate anterior end; posterior end slightly tapering to a small, bluntly rounded, short cauda; one ring-shaped paramylon body.

Sites: Chiang Mai – garden ponds (AG, PK), fish ponds (UM, MJ1, MJ2); Lampang – fish pond (KL), rice paddy (RF); Lamphun – ditch (LL), field ponds – (BL, LP1); Chiang Rai – fish pond (CC1), garden ponds (BY1, BY2); Phayao – ditch (AS); Payao – garden pond (PS).

General occurrence. Cosmopolitan.

Phacus platyaulax Pochmann 1942 Figs 4e & 5e

Cells 45.0–52.5 µm long and 27.5–35.0 µm wide, broadly ovoid, asymmetric, twisted, with longitudinal median groove; short cauda; two large lateral and *ca* 6 small disc-shaped paramylon bodies.

Sites: Chiang Mai – garden ponds (AG, PK), fish ponds (UM, MJ1, MJ3); Lampang – fish ponds (KL, TJ), rice paddy (RF); Lamphun – field ponds (BL, LP1), ditch (LP2); Chiang Rai – fish pond (CC1), garden ponds (BY1, BY2); Phayao – ditch (AS), fish pond (PS1).

General occurrence. Common.

Phacus pleuronectes var. ***minuta*** Playfair 1921 Figs 4f & 5f

Cells 25–35 µm long and 15.0–17.5 µm wide, ovoid; slightly curved cauda; pellicle striated, striations full or dotted; usually one or two large ring- or disc-shaped paramylon bodies.

Note. It differs from the nominative variety by having half-smaller cell dimensions.

Sites: Chiang Mai – fish pond (UM).

General occurrence. Rarely reported.

Phacus pleuronectes var. ***prunoideus*** (Roll) Popova 1955 Figs 4g & 5g

Cells (27.5–)30.0–32.5 µm long and (18.0–)20.0–22.5 µm wide, ovoid, triangular in outline; slightly curved cauda; pellicle striations full or dotted; usually one or two smaller ring- or disc-shaped paramylon bodies.

Note. It differs from the nominative variety by having cells triangular in outline and pellicle striation sometimes built of lines of small papillae.

Sites: Chiang Mai – garden pond (AG), fish ponds (UM, MJ1, MJ2); Lampang – fish ponds (KL, TJ); Lamphun – ditch (LL), fish pond (BL), field pond (LP); Chiang Rai – fish pond (CC1), garden pond (BY1); Phayao – ditch (AS).

General occurrence. Probably common.

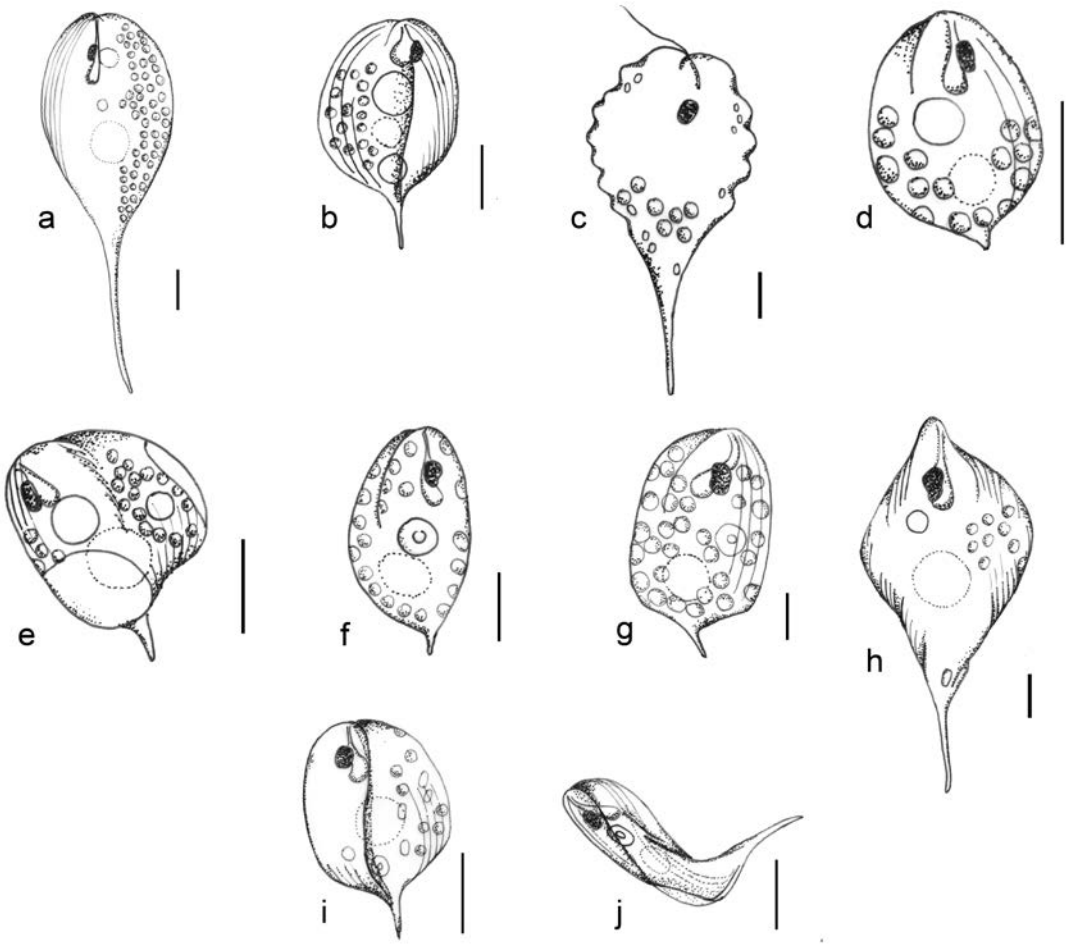

Fig. 4. a – *Phacus longicauda* var. *attenuata* (Pochmann) Huber-Pestalozzi, b – *Ph. mangini* var. *inflata* Nygaard, c – *Ph. morii* Skvortzov, d – *Ph. parvulus* Klebs, e – *Ph. platyaulax* Pochmann, f – *Ph. pleuronectes* var. *minuta* Playfair, g – *Ph. pleuronectes* var. *prunoideus* (Roll) Popova, h – *Ph. sesquitortus* Pochmann, i – *Ph. tortuosus* Roll, j – *Ph. trimaginatus* Allorge & Jahn. Scale bars = 10 µm.

* ***Phacus sesquitortus*** Pochmann 1942 Figs 4h & 5h

Cells 75.0–92.5 µm long and 37.5–42.5 µm wide, broadly obovoid cell, pear-shaped, twisted 1.5 times; cauda long, straight, sharp; usually a single large (or small) circular plate- or ring-shaped paramylon body.

Sites: Chiang Mai – garden pond (AG); Lampang – fish pond (KL); Chiang Rai – garden pond (BY2).

General occurrence. Rarely reported, not common.

Phacus tortuosus Roll 1925 Figs 4i & 5i

Cells 32.5 µm long and 22.5 µm wide, irregularly round; S-shaped apical groove twisted, reaching to 3/4 of cell length; sharply curved cauda.

Sites: Lampang – fish pond (KL).

General occurrence. Not common.

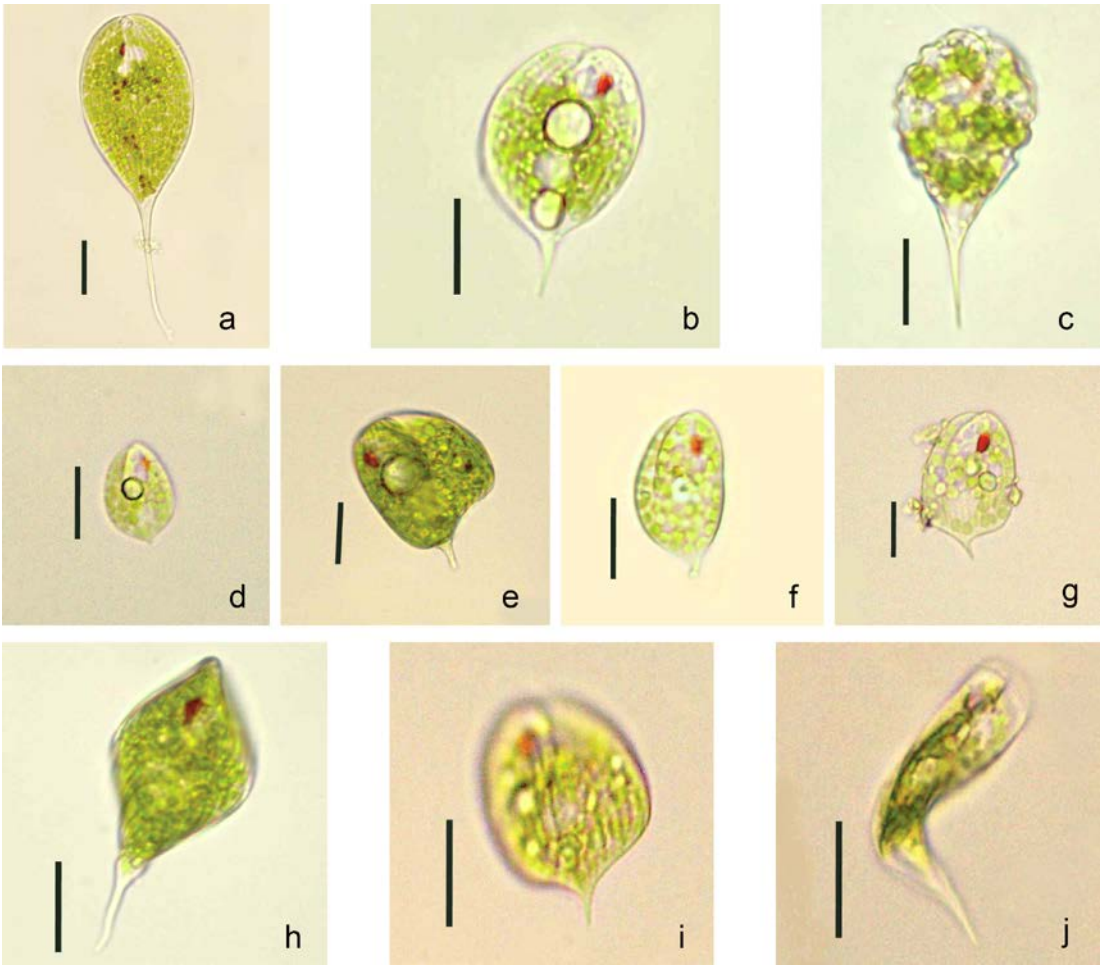

Fig. 5. a – *Phacus longicauda* var. *attenuata* (Pochmann) Huber-Pestalozzi, b – *Ph. mangini* var. *inflata* Nygaard, c – *Ph. morii* Skvortzov, d – *Ph. parvulus* Klebs, e – *Ph. platyaulax* Pochmann, f – *Ph. pleuronectes* var. *minuta* Playfair, g – *Ph. pleuronectes* var. *prunoideus* (Roll) Popova, h – *Ph. sesquitortus* Pochmann, i – *Ph. tortuosus* Roll, j – *Ph. trimaginatus* Allorge & Jahn. Scale bars = 10 µm.

Phacus trimaginatus Allorge & Jahn 1943
Figs 4j & 5j

Cells 40–47 µm long and 12.0–13.5 µm wide, longitudinally ovoid, gutter-shaped, folded along a longitudinal axis and slightly twisted spirally with three longitudinal ribs; short curved cauda; three paramylon bodies thick and rod-shaped.

Sites: Chiang Mai – fish pond (UM); Lampang – fish pond (KL) Lamphun – ditch (LL); Chiang Rai – fish pond (CC1), garden pond (BY, BY2).

General occurrence. Not common.

Conclusions

We found 64 taxa of *Phacus* and only two taxa of *Monomorphina* at 31 sites of different water bodies in Thailand (Duangjan *et al*., unpublished). Twenty five of those *Phacus* taxa and one of the *Monomorphina* taxa are new records for Thailand.

The taxa most frequently occurring at the studied sites included *Ph. acuminatus* Stokes, *Ph. orbicularis* Hübner, *Ph. longicauda* (Ehrenberg) Dujardin, *Ph. pleuronectes* (O. F. Müller), *Ph. salina* (Fritsch) Linton & Karnkowska and *Ph. triqueter* (Ehrenberg) Dujardin. We noted several taxa rarely reported worldwide: *Ph. asymmetricus* first reported by Sokoloff (1933) from a botanical garden in Mexico; *Ph. contortus* fo. *minor*, described by Bourrelly (1961) from the Ivory Coast, Central Africa; *Ph. sesquitortus*, described from Australia by Pochmann (1942); *Ph. trimarginatus*, reported by Allegre and Jahn (1943) from Iowa, U.S.A.; *Ph. morii*, reported by Skvortzov (1928) from Seoul, Korea. All of the above species have been found in tropical regions. Three of them are new for Southeast Asia (*Ph. asymmetricus*, *Ph. contortus* fo. *minor*, *Ph. sesquitortus*).

We recognized several varieties of *Phacus acuminatus* (var. *indica*, var. *acuticauda* and var. *javana*). We also found *Ph. pleuronectes* var. *minuta* and *prunoideus* and *Ph. contortus* fo. *minor*, which are barely distinguishable from the nominative variety. For now their status as varieties is confirmed only by morphological features. According to GenBank data, most of the reported taxa and varieties have not yet been studied by molecular methods; the only ones checked by molecular studies on various levels are *Monomorphina pseudopyrum*, *Phacus alatus*, *Ph. inflexus Ph. parvulus*, *Ph. platyaulax* and *Ph. trimarginatus* (GenBank, http://www.ncbi.nlm.nih.gov/genbank).

According to Starmach (1983), the members of *Phacus* usually occur in swamps, overgrown ponds, rivers and bogs together with other euglenoid genera. He also noted that representatives of *Phacus* avoid heavily polluted waters but our study does not confirm that statement. All the water bodies we studied were strongly polluted by organic matter. High pollution and temperature favored the development of *Phacus*. We also observed rare blooming of *Phacus* taxa such as *Phacus triqueter* (Ehrenberg) Dujardin. We suggest that the high diversity of *Phacus* at the studied sites is most likely due to high temperature and high pollution of the water by organic substances.

Most of the taxa reported as new for Thailand are well known in Europe, North America and South America, and regarded as cosmopolitan around the world. We also observed that the morphological characters of the studied taxa are more variable than those from moderate climate (Wołowski 1992, 1998; Wołowski & Hindák 2005). Representatives of this genus are important organisms for use together with other algae as indicators of water pollution in tropical countries.

Acknowledgements. We thank Professor Pertti Eloranta and the anonymous reviewer for helpful remarks and suggestions on the manuscript. This research was supported by grants from the Royal Golden Jubilee PhD Program of Thailand and by the statutory fund of the W. Szafer Institute of Botany, Polish Academy of Sciences.

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Received 15 October 2014